BENTON HARBOR POWER PLANT LIMNOLOGICAL STUDIES

PART XXVIII

ENTRAINMENT OF PHYTOPLANKTON AT THE DONALD C. COOK NUCLEAR PLANT - 1978

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INTRODUCTION

The Donald C. Cook Nuclear Plant is a 2,200 megawatt steam electric generating station situated on the southeastern shore of Lake Michigan about 18 km south of St. Joseph, Michigan. At full operation, the plant uses roughly 6,300 m^3/min of lake water in once-through cooling of its condensers. As required by the Technical Specifications for the plant, waste heat is returned to the lake in cooling water heated to a maximum of 12-13 C° above intake temperature for unit #1 and 9-10 C° above lake temperature for unit #2 as stated in the Technical Specifications for the plant. The plant uses chlorination twice daily for chemical defouling of heat exchangers and turbine condensers.

The Environmental Technical Specifications of the plant require an assessment of phytoplankton abundance, viability, and species composition to be made on a monthly basis on samples collected in the early morning, at mid-day, and in the late evening.

SUMMARY AND APPLICATION TO THE DONALD C. COOK NUCLEAR PLANT

Studies described in the literature are summarized in Rossmann _et al._ (1977). These have shown that phytoplankton may suffer inhibition or death due to entrainment and condenser passage. In addition, changes in community structure have been noted. Various authors have concluded that temperature rises which can be tolerated by phytoplankton range from 8 C° to 11 C°. The actual temperature change that can be tolerated by phytoplankton is related to the intake water temperature; the lower the intake water temperature the greater the tolerable temperature rise (See Rossmann _et al._ 1977). If chlorination is also taking place, phytoplankton may be killed outright or

suffer varying degrees of inhibition. At elevated temperatures, communities have been observed to exhibit a decreased diversity promoted by a shift from a diatom dominated community to one dominated by either green algae or blue-green algae. Finally, some evidence exists which suggests that the phytoplankton productivity may be mildly stimulated by mechanical pumping (Gurtz and Weiss 1972).

PREVIOUS STUDIES AT THE COOK PLANT

In response to the above possible alterations of the phytoplankton community in the vicinity of the power plant, two major studies have been initiated. The first study, begun in 1968, is directed at determining the long-term effect of the plant on the phytoplankton. This study includes the counting and identification of phytoplankton species at both plant-influenced and non-influenced sites. These data have been used to establish pre-operational phytoplankton trends and variations in the lake against which operational data can be compared. The results of these studies have been reported by Ayers *et al*. (1970), Ayers *et al*. (1971), Ayers *et al*. (1972), Ayers and Seibel (1973), Ayers *et al*. (1974), Ayers and Kopczynska (1974), Ayers (1975a), Ayers (1975b), Ayers *et al*. (1977), Ayers (1978), and Ayers and Wiley (1979).

The second study is to ascertain the immediate effect of the plant on the entrained phytoplankton. This study will also be used to monitor long-term changes in the phytoplankton. Results of this continuing study for the year 1978 are presented here. The monitoring results for 1975, 1976, and 1977 are found in Rossmann *et al*. (1977), Rossmann *et al*. (1979), and Rossmann *et al*. (1980), respectively.

SAMPLING HANDLING AND ANALYSIS

Studies pertaining to entrained phytoplankton at the Donald C. Cook Nuclear Plant unit #1 began in February 1975 and continue at present. Investigation of plant impact on phytoplankton viability, abundance, and species composition has been made in accordance with the Environmental Technical Specifications for the plant. Sampling was conducted on a monthly basis with three approximately one-half hour sampling periods in a 24-hour span: after evening twilight, before morning twilight, and at noon. During each sampling period, fourteen samples were collected; seven from the intake forebay and seven from the discharge forebay (Figure 1). Two of the seven samples were preserved for microscopic investigation of phytoplankton abundance and species composition. The remaining five samples were used for spectrophotometric determination of chlorophylls *a*, *b*, and *c* and phaeophytin *a*. During the first evening sampling period, five additional samples were collected from both the intake and discharge forebays. These samples were incubated at the intake temperature for approximately 36 hours and treated in the same manner as non-incubated samples for analysis of the chlorophylls and phaeophytin *a*.

Throughout 1978, samples were collected at intake grate MTR 1-5 from a depth of 5.5 m. A new study of horizontal and vertical phytoplankton concentrations in the intake forebay with all seven circulating pumps running was conducted at MTR 1-2, MTR 1-5, MTR 2-1, and MTR 2-5 at depths of 0.6, 5.5, and 8.5 m.

Water was collected by diaphragm pumps from the intake and discharge

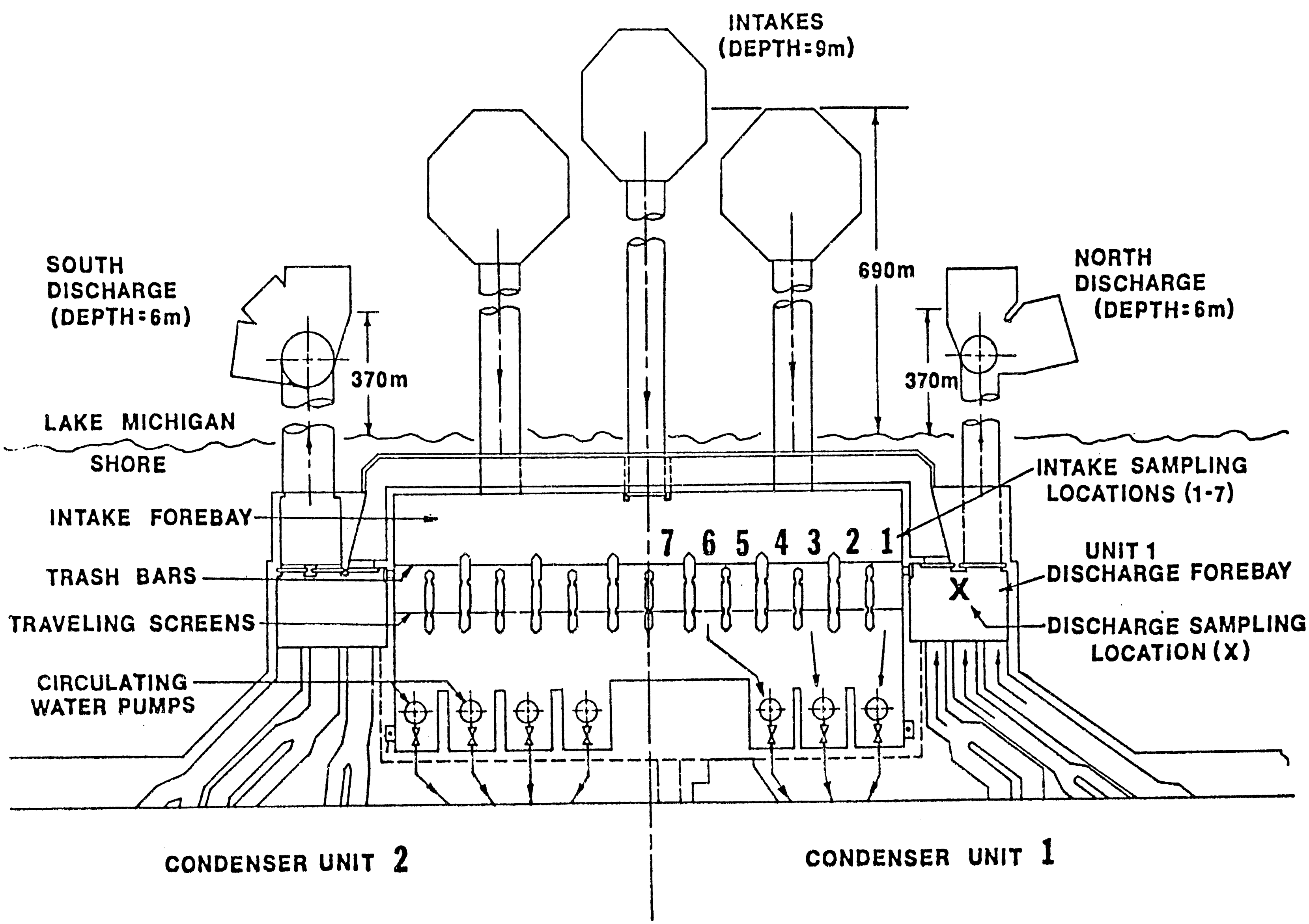

FIG. 1. Sampling locations in the Donald C. Cook Nuclear Plant screenhouse.

forebays through 3-inch hoses at a rate of roughly 227 L/min. As the water was pumped, the intake and discharge water temperatures were measured, and samples were collected in 1-L polyethylene bottles. Since unit #1 uses 2.7×10^6 L/min for cooling, the samples collected during a one-half hour sampling time represent approximately 6.2×10^{-6}% of the water passing through the plant for the chlorophylls and 2.5×10^{-6}% of the water passing through the plant for the microscopic phytoplankton analysis. During two unit operation, 6.2×10^6 L/min of water are used for cooling. Thus chlorophyll samples represent 2.7×10^{-6}% and phytoplankton samples represent 1.1×10^{-6} % of the water passing through the plant.

PHYTOPLANKTON

Phytoplankton samples were collected from both the intake and discharge forebays (Figure 1). They were, for the most part, collected in duplicate in 1-L brown polyethylene bottles (triple rinsed with lake water) and fixed with 6 mL of Lugols' solution. Slide preparation was similar to the settle-freeze method of Sanford et al. (1969). One-liter samples were settled in graduated cylinders for 2 days, after which time 900 mL of supernatant were siphoned off. The remaining 100 mL were then agitated to resuspend the settled matter, and 18 mL were poured into a cylindrical plexiglass settling chamber with a microscope slide at its base. Various dilutions were used to facilitate enumeration and identification when there were high concentrations of suspended material. The chambers were secured to the slides with a minimal amount of stopcock grease on their ends and the cylinder-slide combinations were held by clamps onto a one-quarter-inch thick aluminum plate. After 2 days of settling, freezing of the bottom 1.5 mL was accomplished by placing the entire apparatus on a block

of dry ice for approximately 25 seconds. The supernatant was poured off and when the ice at the bottom of the chamber had melted sufficiently, the chamber was removed from the slide, and the slide with its thin wafer of ice and water was dehydrated in an anhydrous alcohol chamber for 2 days. This was followed by 2 days in a toluene chamber to prepare the sample for permanent mounting under a cover slip in Permount.

All counting was done on a Leitz Ortholux microscope at 1250X with a stage micrometer calibrated field width of 100 m. Identification of specimens was carried to species and variety when possible. Enumeration was all in cells per milliliter except for blue-green filaments with cylindrical trichomes which were in filaments per milliliter. Two complete transects were made across each slide, one horizontal and one vertical, to help offset any patchiness that could occur in distribution. A minimum of 500 cells was counted for each slide to ensure reasonable group percentages; more transects and/or higher counts were necessary if a fairly large number or proportion of the cells were in colonial formations.

CHLOROPHYLLS AND PHAEOPHYTIN a

Each water sample was passed through a 4.25-cm diameter Whatman GF/C glass fiber filter. After most of the water had passed into the filtering flask, 1 mL of saturated $MgCO_3$ was added (1 g $MgCO_3 \cdot 4H_2O$/100 g distilled water) and filtration taken to dryness. The filters were rolled up with the forceps, placed in amber vials, frozen, and transported back to the laboratory. The samples selected for incubation were not filtered but immediately placed in an incubator with the bottle caps removed and allowed to incubate for 24 to 48 hours at the intake temperature. Following this, they were filtered and

treated in the same manner as the non-incubated samples.

In the laboratory, the frozen samples were prepared for analysis using the Strickland and Parsons (1972) method by grinding with a tissue grinder and extracting into 90% acetone. The 90% acetone was prepared by swirling reagent grade acetone with anhydrous Na_2CO_3 and passing it through a Whatman #4 filter (containing some additional Na_2CO_3) into a volumetric flask having the appropriate volume of distilled water for a 90% solution (v/v). Sample vials were removed from the freezer in groups of five and placed on ice in a dark ice chest next to the grinding apparatus. Sample vials were removed singly from the ice chest, and the frozen filters were transferred with forceps to a tissue grinding tube immersed in an icebath. The filter was ground at approximately 100 rpm for 4 minutes in 1.5 - 2 mL of 90% acetone in a tissue grinding tube; the grinding tube was held firmly against the rotating pestle, lowered briefly, and raised back against the pestle approximately every 15 seconds. If the filter and 90% acetone were not reduced to a homogeneous slurry after 4 minutes, grinding was continued until this was accomplished, generally within 1 minute. The contents of the grinding tube were then poured into a 12-mL screw cap centrifuge tube. The tissue grinder was rinsed three times with 90% acetone into the centrifuge tube to adjust the final volume of 90% acetone to 10 mL. The centrifuge tube was then capped and placed in the ice chest. After all five samples were ground, they were placed in a dark refrigerator and allowed to extract for 24 - 36 hours. Following extraction, each sample was inverted three times and centrifuged with the tube in an ice bath for 4 minutes at 2,000 rpm to separate the filter fibers and $MgCO_3$ from the extract. The centrifuged samples were then refrigerated until shortly before analysis.

For analysis, individual samples were warmed to room temperature in a

light tight container. The extract was transferred by a pasteur pipette to two 5-cm-path long cuvettes. Two drops of 50% v/v HCl were added to the sample in one cuvette, which was shaken and then held for 4 minutes. The other cuvette was placed in a Beckman model 25 spectrophotometer where sample absorbances were measured over a scan from 600 to 750 nm. The absorbance of the acidified sample was then measured over the same range.

CONDITIONS AT TIME OF COLLECTION

TEMPERATURE AND PHYSICAL EVENTS

Table 1 contains a summary of intake and discharge temperatures for those periods of time when phytoplankton entrainment samples were collected. During June and July 1978, phytoplankton collection coincided with large rapid temperature changes due to upwelling of colder bottom water along the eastern shore of Lake Michigan in the vicinity of the Donald C. Cook Nuclear Plant. The temperature decrease in June occurred at the very end of the sampling period. Upwelling transports colder bottom water, rich in nutrients and containing its own phytoplankton assemblage, to nearshore regions of the lake. Mixing of cold bottom water with warmer surface water yields a water mass having characteristics of each and results in an increased heterogeneity, which has the important effect of increasing sampling error if the upwelling occurs during a sampling period.

CHLORINATION

Chlorination occurs twice daily at the Donald C. Cook Nuclear Plant. In

TABLE 1. Intake and discharge entrainment temperatures at the time of sampling during 1978.

Date	Time	Intake, °C	Discharge #1, °C	Discharge #2, °C
January 10, 1978	Morning Twilight	3.0	13.5	--[1]
11	Noon	2.8	14.0	--
11	Evening Twilight	5.6	17.0	--
February 6, 1978	Evening Twilight	0.8	10.6	--
7	Morning Twilight	0.8	10.9	--
7	Noon	0.8	10.2	--
March 6, 1978	Evening Twilight			--
7	Morning Twilight	0.8	12.1	--
7	Noon	0.6	1.6	--
April 10, 1978	Evening Twilight	4.2	--	8.7
11	Morning Twilight	2.8	--	8.1
11	Noon	4.8	--	10.2
May 9, 1978	Evening Twilight	8.9	--	17.6
10	Morning Twilight	9.9	--	18.8
10	Noon		--	17.8
June 12, 1978	Evening Twilight	17.8	--	26.3
13	Morning Twilight	17.8	--	25.8
13	Noon	9.9	--	11.0
July 10, 1978	Evening Twilight	10.0	21.5	15.2
11	Morning Twilight	11.0	21.5	16.4
11	Noon	10.7	22.2	17.7
August 7, 1978	Evening Twilight	19.0	31.0	28.2
8	Morning Twilight	20.8	32.2	30.0
8	Noon	21.0	32.6	29.9
September 11, 1978	Evening Twilight	26.5	36.5	35.1
12	Morning Twilight	26.2	36.0	35.1
12	Noon	25.1	36.0	35.0
October 9, 1978	Evening Twilight	17.4		25.0
10	Morning Twilight	15.1	26.0	23.2
10	Noon	16.8	26.7	25.0
November 13, 1978	Evening Twilight	11.2	22.0	--
14	Morning Twilight	11.1	21.8	--
14	Noon	11.0	21.6	--
December 4, 1978	Evening Twilight	4.8	15.2	13.3
5	Morning Twilight	4.8	15.6	14.0
5	Noon	4.8	14.8	13.9

[1] Unit not operating

each case, the period of chlorination is one-half hour. Table 2 is a compilation of the chlorination times for those days on which phytoplankton entrainment studies were conducted in 1978. Our sampling periods never coincided with chlorination.

RESULTS AND DISCUSSION

NUTRIENTS

During 1978, samples for nutrient analyses were collected in triplicate from the intake forebay of the plant at location MTR 1-5. Collection coincided with the noon sampling period for phytoplankton. Each sample was analyzed for orthophosphate, nitrate, nitrite, and dissolved reactive silica. The methodology used is described in Rossmann *et al.* (1979) and the quality control is described in Rossmann *et al.* (1980).

Concentrations of each of the nutrients varied throughout the year in response to upwelling, storm events, and utilization by the phytoplankton (Table 3). Nitrite was only detectable during May. During July, sample collection coincided with large temperature changes due to upwelling of colder bottom water along the eastern shore of Lake Michigan in the vicinity of the Donald C. Cook Nuclear Plant. This upwelling maintained the orthophosphate concentration above 1.0 ppb and increased the dissolved silica concentration to 1.0 ppm. Dissolved silica began to decrease in May with commencement of the spring diatom bloom. Its concentration was low until the end of thermal stratification in October. Mixing of epilimnetic and hypolimnetic waters provided dissolved silica-rich waters to this nearshore region of the lake.

TABLE 2. Chlorination times on the days of phytoplankton entrainment studies during 1978.

Date	Unit #1 Time, EST	Unit #2 Time, EST
January 10	0900-0930, 2100-2130	--[1]
11	0900-0925, 2100-2130	--
February 6	--	--
7	--	--
March 6	--	--
7	--	--
April 10	--	--
11	--	--
May 9	--	--
10	--	--
June 12	--	--
13	--	--
July 10	--	--
11	--	--
August 7	0900-0940, 2100-2140	--
8	0905-0935, 2100-2135	--
September 11	--	--
12	0900-0935, 2100-2130	0945-1015, 2145-2215
October 9	--	--
10	0900-0935	0945-1015
November 13	0805-0830	--
14	--	--
December 4	1000-1030	1035-1105
5	--	--

[1]Unit not operating or no chlorination.

Dissolved silica concentrations were low again in November, signalling commencement of the winter diatom bloom.

PHYTOPLANKTON

Monthly Variations of Entrained Major Phytoplankton Groups

The major groups of phytoplankton under consideration are coccoid blue-green algae, filamentous blue-green algae, coccoid green algae,

TABLE 3. Monthly variation of nutrients during 1978.[1]

Month	Orthophosphate PO_4^{2-}-P, ppb	Nitrate-N, ppm	Nitrite-N, ppm	SiO_2, ppm
January	4.1 (0.18)	0.45 (0.021)	0.0 (0.0)	0.87 (0.019)
February	1.0 (0.46)	0.29 (0.0034)	0.0 (0.0)	0.76 (0.0055)
March	2.0 (0.15)	0.27 (0.020)	0.0 (0.0)	1.1 (0.046)
April	1.4 (0.76)	0.38 (0.17)	0.0 (0.0)	0.90 (0.099)
May	2.6 (0.34)	0.16 (0.019)	0.025 (0.0036)	0.46 (0.019)
June	1.9 (0.071)	0.17 (0.0056)	0.0 (0.0)	0.56 (0.19)
July	1.1 (0.058)	0.16 (0.034)	0.0 (0.0)	1.0 (0.058)
August	0.14 (0.0012)	0.12 (0.0077)	0.0 (0.0)	0.71 (0.030)
September	0.61 (0.070)	0.0 (0.0)	0.0 (0.0)	0.36 (0.039)
October	0.36 (0.028)	0.079 (0.043)	0.0 (0.0)	0.77 (0.012)
November	0.86 (0.26)	0.084 (0.028)	0.0 (0.0)	0.83 (0.07)
December	0.38 (0.14)	0.054 (0.0041)	0.0 (0.0)	0.48 (0.17)

[1]Means are followed by standard deviations in parentheses.

filamentous green algae, flagellates, centric diatoms, pennate diatoms, desmids, and other algae. With the exception of the desmids, whose population level is relatively low throughout the year, all major groups represent significant contributions to the composition of the total algal assemblage. The succession of diatoms, blue-green algae, green algae, and flagellates is of importance in this system (Rossmann et al. 1979). These succession patterns are predictable throughout the calendar year.

In general, diatoms contribute the largest numbers to the total annual algal assemblage and include two major groups: centric and pennate diatoms. These groups, which have a close ecological affinity, are relatively abundant in spring (Rossmann et al. 1977, 1979, 1980). They reach their peak in April

and decrease thereafter. This decrease in abundance after April is related to the onset of thermal stratification which isolates the surface waters from the pool of nutrients in the hypolimnion. An increase in diatoms increases the utilization of nutrients and produces a nutrient depletion, especially depletion of dissolved silica which is essential for the growth of diatoms. The low population density continues until October when a decrease of water temperature and physical mixing processes create an isothermal water column. During the establishment of an isothermal water column, nutrients such as dissolved silica are replenished, leading to a relatively high density of diatoms throughout the winter months.

The green algae population, including coccoid green and filamentous green algae, is generally low from January through May or June. It reaches a peak density during the warm water months of May through September, and then declines during October through December.

Blue-green algae are low in concentration during January through April or July. Population abundance is highest during June through October when water temperatures are relatively high, and its abundance decreases in November and December with decreased water temperature.

Flagellates are relatively low in concentration during January through March. A population peak generally occurs in April or May, and a large population often continues through December.

The patterns of succession described above serve as a general temporal distribution of species occurring in the offshore waters of Lake Michigan, but they are seldom completely coincident with the species found in the nearshore region of Lake Michigan where factors dominating the system vary greatly from year to year in degree or in time of occurrence. Furthermore, in the case of

the entrainment samples, thermal effluents from the power generating plant offer an additional variable which may cause further deviation or may offset the described patterns of succession. Since the general pattern of succession does not fully describe the existing yearly microvariations, it would be of benefit to look at the observed patterns of 1978 algal succession. The complete results of microscopic counting of the 1978 phytoplankton entrained are in the Appendix.

Coccoid blue-green algae had a low population density in March, April, and May, reached a peak in June, and decreased during July and August. They increased rapidly in September and October and remained high throughout the rest of the year (Table 4 and Figure 2). Comparisons between the total abundance of the coccoid blue-green in 1978 with those in 1975, 1976, and 1977 indicate a marked increase.

Filamentous blue-green algae were less numerous than coccoid blue-green algae in 1978 (Table 5 and Figure 3). Peaking in June and August, the maximum count was 111 cells/mL. The comparison between abundance of 1978 and those of 1975, 1976, and 1977 showed an increase in the 1978 population with respect to the 1977 one, but a decrease with respect to those of 1975 and 1976.

Coccoid green algae abundances were low throughout the early part of 1978 until the month of May (Table 6 and Figure 4). A relatively high population occurred in August through December. There was an increase in mean population density between 1978 and 1977 but a reduction between 1978 and 1975 and 1976.

Filamentous green algae were less numerous than coccoid green algae and had a population density above 15 cells/mL only in November and December 1978

TABLE 4. Monthly variation of coccoid blue-green algae during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	461.(149)			296.(91.8)
February	109.(59.7)	254.(71.7)		95.0(50.0)
March	257.(186.)	347.(110.)	137.(57.2)	28.7(12.6)
April	312.(125.)	143.(63.6)	110.(76.2)	78.8(30.7)
May	689.(169.)	87.1(46.6)	47.3(27.3)	143.(54.5)
June	235.(155.)	33.6(25.1)	114.(45.6)	521.(166.)
July	1050.(155>)	57.8(26.5)	133.(28.5)	244.(75.7)
August	286.(53.2)	439.(93.8)	1210.(254.)	149.(35.4)
September	1220.(169.)	339.(118.)	917.(93.6)	660.(80.4)
October	945.(212.)	560.(196.)	727.(145.)	2353.(365.)
November	600.(166.)	422.(121.)	1320.(289.)	1992.(278.)
December	176.(106.)	275.(73.4)	872.(124.)	3642.(363.)
Yearly Mean	535.(117.)	285.(50.1)	559.(159.)	850.(134.)

* Mean is followed by the standard error.

(Table 7 and Figure 5). A slight reduction in the 1978 population mean relative to the previous 3 years was encountered.

Flagellates were numerous and contributed a large portion to the total annual algal population (Table 8 and Figure 6). They had a relatively high density in April, May, and June, reached their peak in June, and maintained a relatively low density during the rest of the year. No significant change in mean annual abundance between 1978 and 1975, 1976, and 1977 was observed.

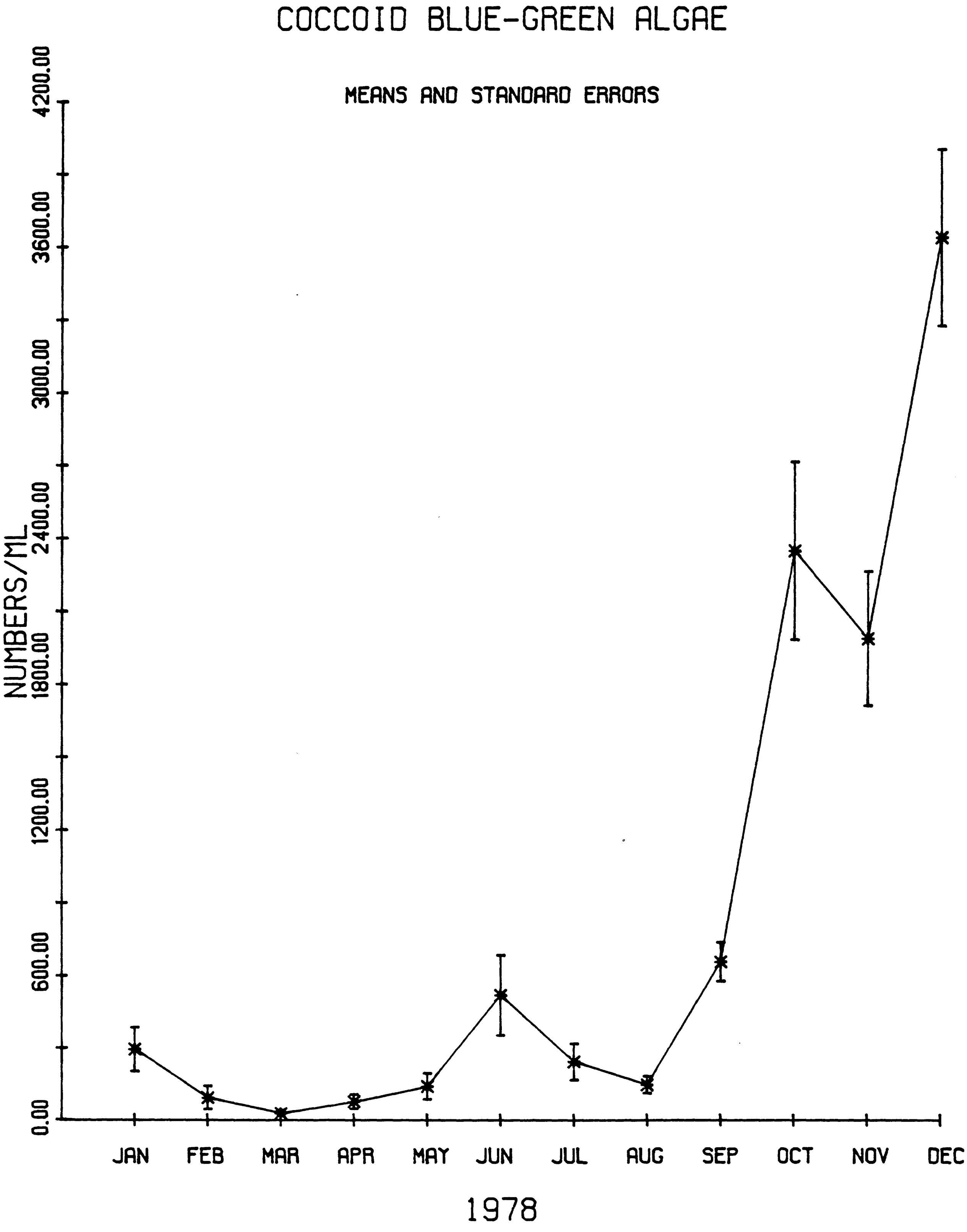

FIG. 2. Variation of coccoid blue-green algae numbers during 1978.

TABLE 5. Monthly variation of filamentous blue-green algae during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January		22.0(8.06)		15.2(5.61)
February	28.2(8.10)	16.4(3.53)		6.22(2.46)
March	59.7(17.6)	13.4(2.53)	16.7(3.19)	3.60(.921)
April	27.6(5.40)	57.9(5.16)	110.(76.2)	2.63(.919)
May	103.(37.0)	457.(52.8)	17.5(4.09)	14.5(4.52)
June	314.(38.1)	81.1(16.1)	24.3(8.29)	111.(51.9)
July	95.1(25.5)	72.1(12.7)	59.9(14.3)	65.0(12.6)
August	8.90(2.70)	9.24(3.08)	17.6(6.37)	111.(26.5)
September	17.3(9.20)	46.8(15.8)	25.0(8.84)	8.89(2.68)
October	98.8(34.0)	45.9(23.8)	21.4(7.61)	87.0(18.9)
November	21.6(17.8)	6.35(4.31)	12.7(3.13)	82.9(18.7)
December	15.4(7.70)	74.5(44.3)	45.2(18.6)	67.9(13.5)
Yearly Mean	71.8(26.5)	75.2(35.6)	35.0(9.54)	48.0(13.3)

* Mean is followed by the standard error.

Centric diatoms were relatively low in abundance in early spring, reached a population peak in May, and decreased thereafter (Table 9 and Figure 7). The high population found in June and July was coincident with upwelling, which often leads to an increase in nutrients including dissolved silica. The population remained relatively low throughout the rest of the year except during October. An increase in mean population density was noted for 1978 relative to 1977, but there was a reduction for 1978 as compared to 1975 and 1976.

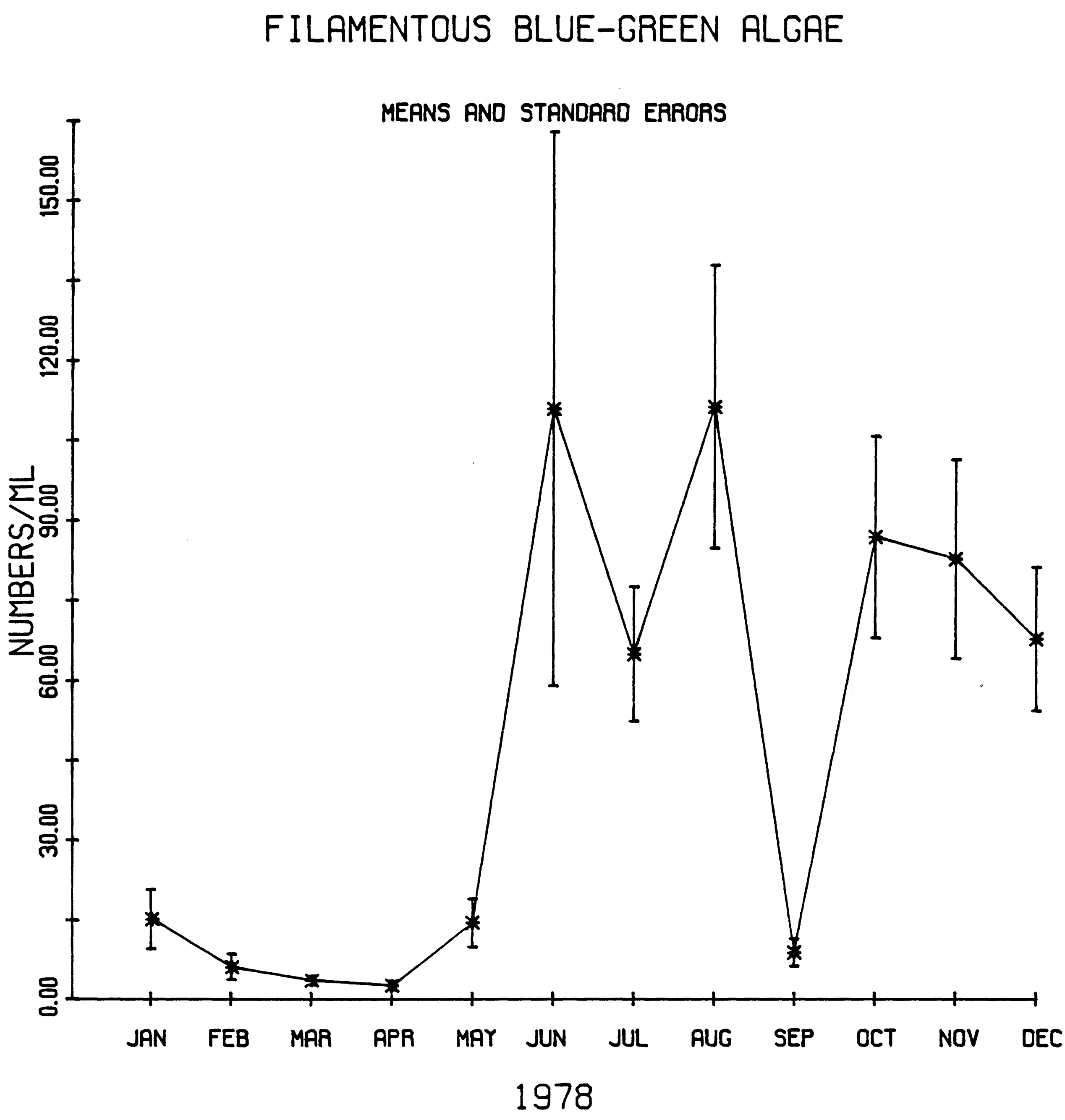

FIG. 3. Variation of filamentous blue-green algae numbers during 1978.

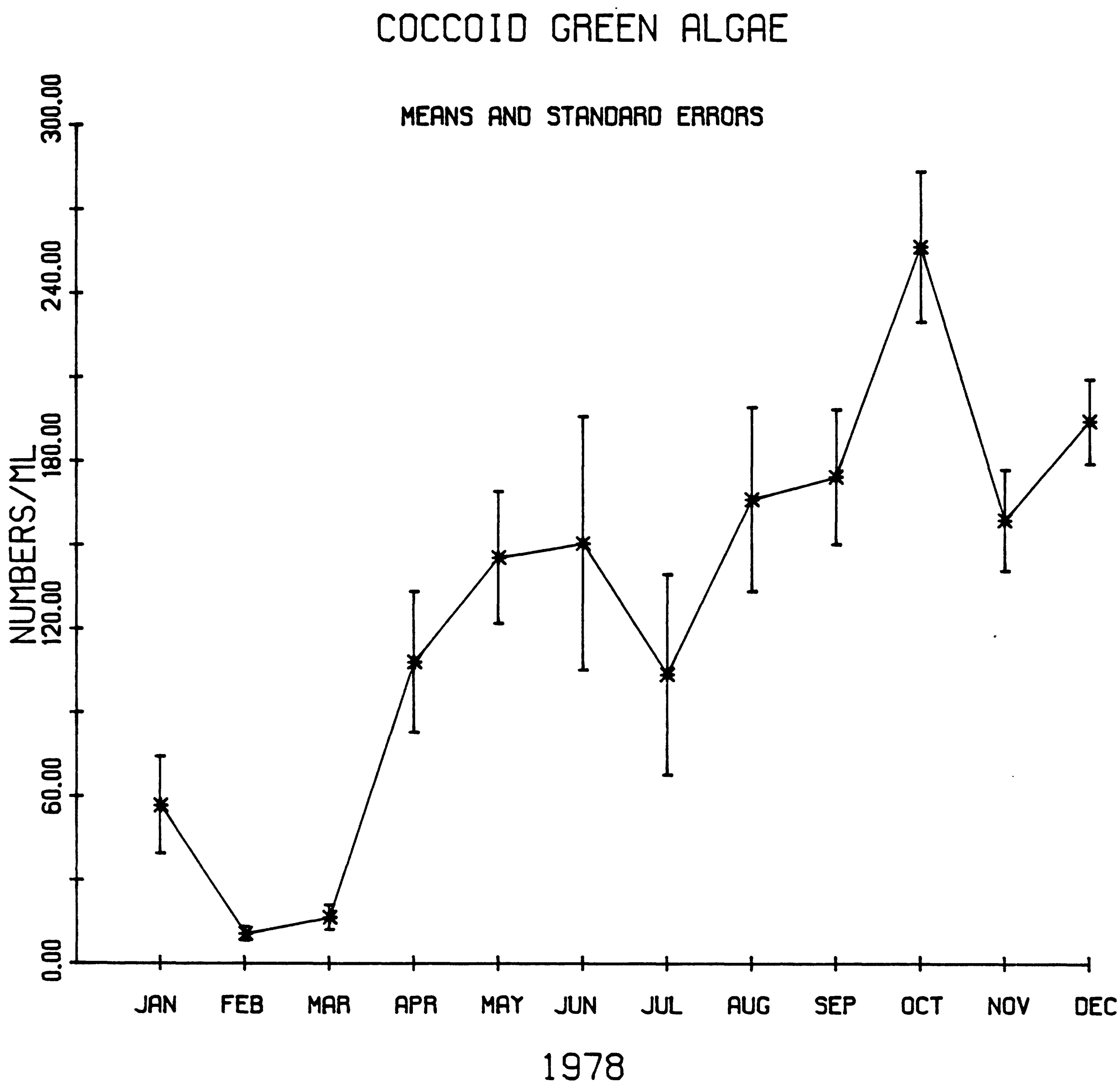

FIG. 4. Variation of coccoid green algae numbers during 1978.

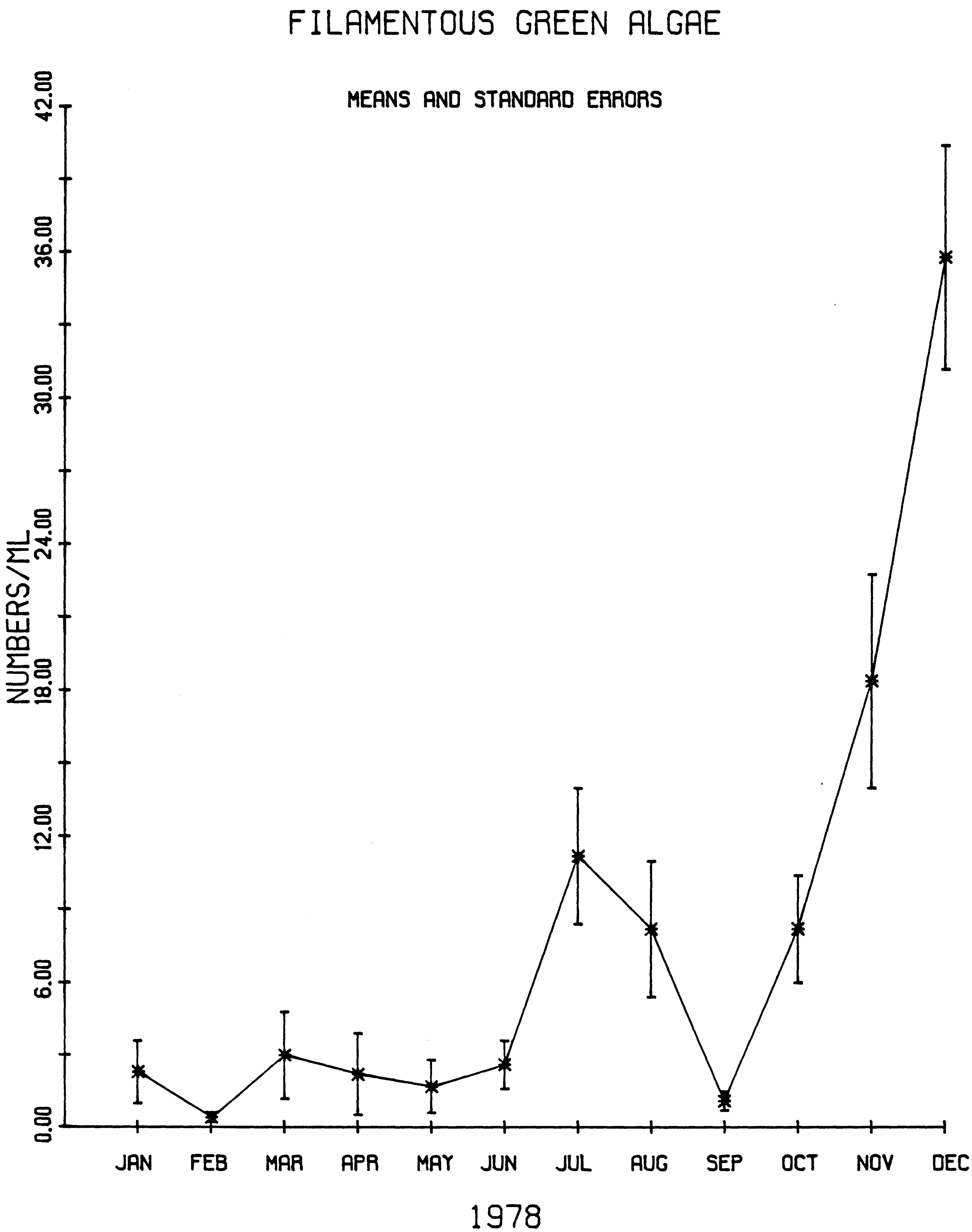

FIG. 5. Variation of filamentous green algae numbers during 1978.

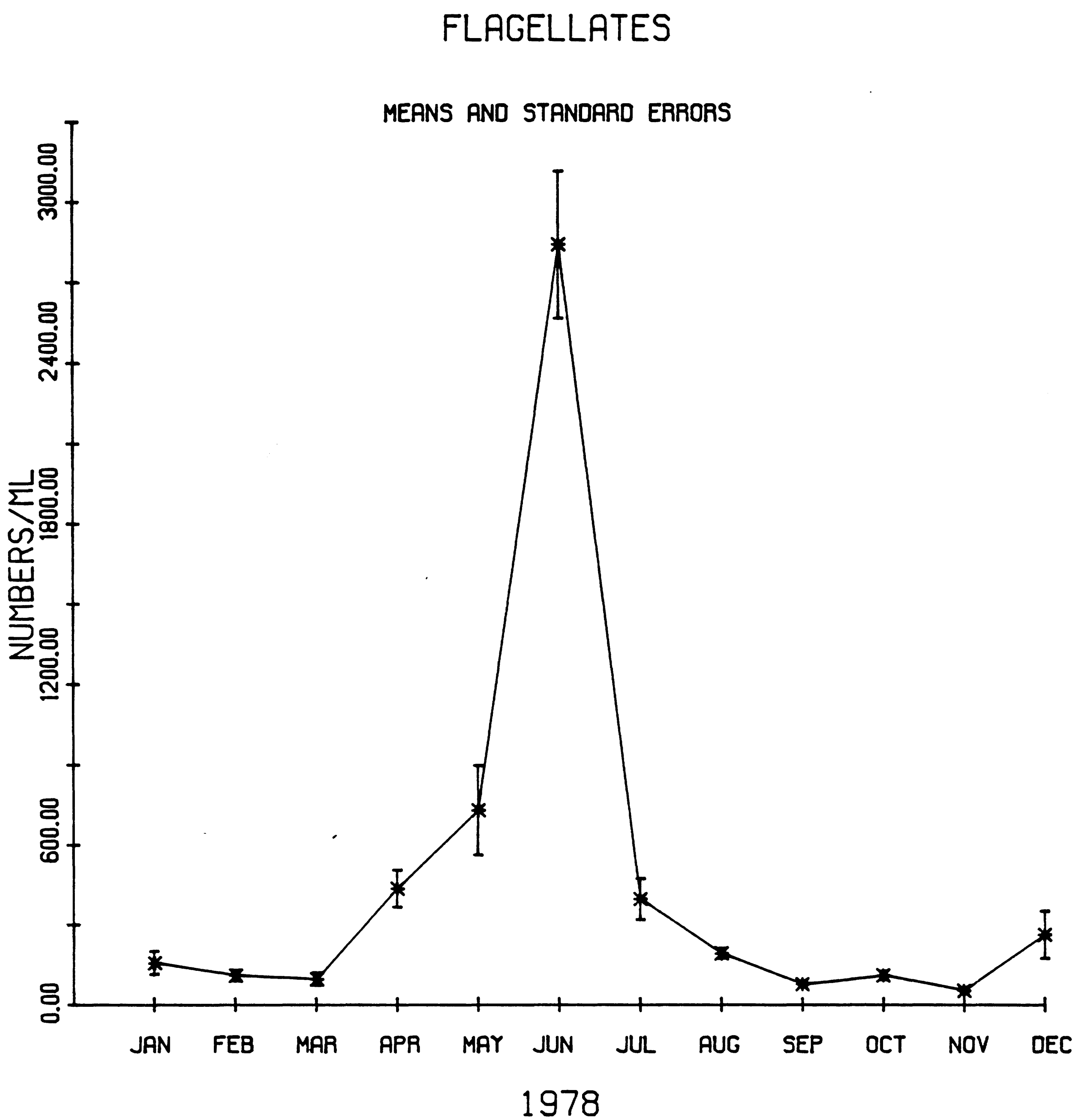

FIG. 6. Variation of flagellated algae numbers during 1978.

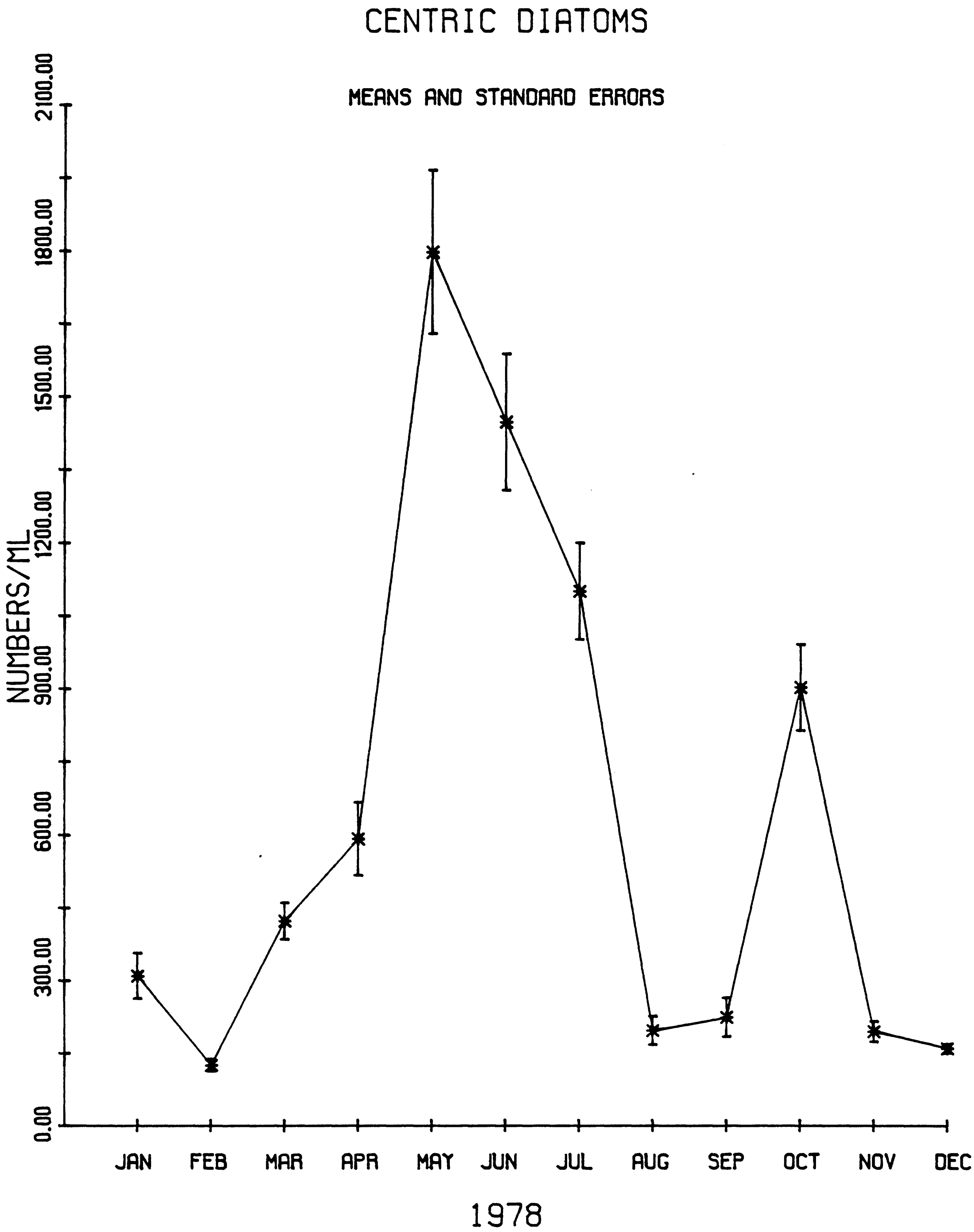

FIG. 7. Variation of centric diatom numbers during 1978.

TABLE 6. Monthly variation of coccoid green algae during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	42.2(12.2)			56.8(17.4)
February	39.3(14.2)	29.5(11.1)		10.7(2.57)
March	55.2(24.7)	22.9(7.63)	21.1(4.43)	16.6(4.54)
April	49.7(14.8)	57.9(12.3)	51.4(8.31)	108.(25.2)
May	47.1(19.7)	145.(30.6)	15.3(4.89)	145.(23.6)
June	141.(23.2)	98.4(26.9)	39.2(15.8)	150.(45.3)
July	1000.(107.)	689.(123.)	152.(19.2)	103.(35.9)
August	197.(37.1)	494.(46.8)	115.(16.5)	166.(32.9)
September	176.(24.2)	755.(129.)	54.4(8.31)	174.(24.1)
October	116.(16.1)	242.(37.1)	232.(85.4)	256.(26.9)
November	138.(66.9)	134.(36.1)	65.1(18.2)	159.(18.1)
December	110.(47.8)	240.(54.5)	49.5(11.4)	194.(15.1)
Yearly Mean	188.(82.8)	246.(74.6)	79.5(21.5)	128.(22.6)

* Mean is followed by the standard error.

Pennate diatoms contributed a large share to the total algal population in 1978 (Table 10 and Figure 8). They were low in density in spring, reached a peak in May, remained high through June and July, and decreased thereafter. This extended high abundance may be attributed, in part, to upwelling. The population density remained low until October when thermal stratification ceased. There was a significant reduction in mean annual density for 1977 relative to 1975 and 1976, but a slight increase for 1978 relative to 1977.

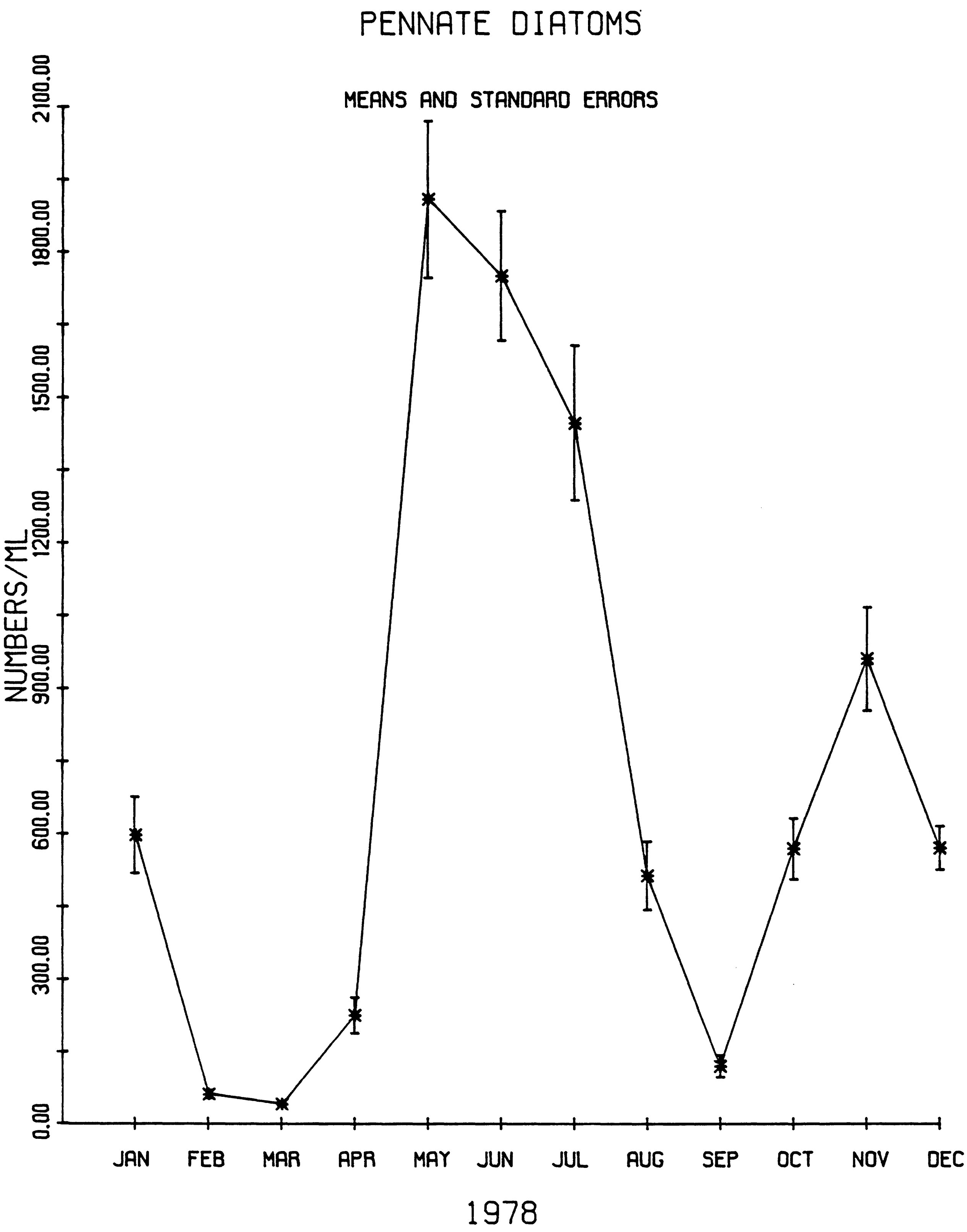

FIG. 8. Variation of pennate diatom numbers during 1978.

TABLE 7. Monthly variation of filamentous green algae during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	31.6(17.4)			2.26(1.35)
February	18.0(9.70)	2.00(1.20)		.350(.241)
March	34.8(12.6)	16.4(6.62)	6.63(4.37)	3.04(1.82)
April	0.0(0.0)	18.1(10.5)	18.2(12.3)	2.21(1.70)
May	1.50(1.50)	57.8(23.0)	4.63(2.32)	1.70(1.15)
June	29.5(20.6)	55.0(14.0)	.417(.417)	2.6 (1.03)
July	0.3(0.3)	37.3(11.1)	22.9(4.79)	11.2(2.81)
August	0.8(0.6)	4.28(2.52)	0.0(0.0)	8.15(2.83)
September	0.2(0.2)	13.7(6.13)	1.86(.888)	1.12(.401)
October	2.8(1.1)	9.67(2.47)	6.63(4.02)	8.19(2.16)
November	1.5(1.2)	6.35(5.48)	26.8(6.92)	18.4(4.37)
December	14.4(7.3)	5.52(2.39)	14.0(6.97)	35.8(4.55)
Yearly Mean	9.44(3.87)	21.5(5.64)	10.2(3.06)	7.92(2.03)

* Mean is followed by the standard error.

Desmids were consistently low in abundance throughout 1978 (Table 11 and Figure 9). The maximum population density did not exceed 3 cells/mL; the peak was in July. No significant change in population was found from 1975 to 1978.

The group of "other algae" is composed of phytoplankton which do not belong to any of the groups mentioned above. This group of phytoplankton reached peaks of abundance in July and October (Table 12 and Figure 10). The population maximum was found in July. An increase in mean population density was noted between 1978 and 1975, 1976, and 1977.

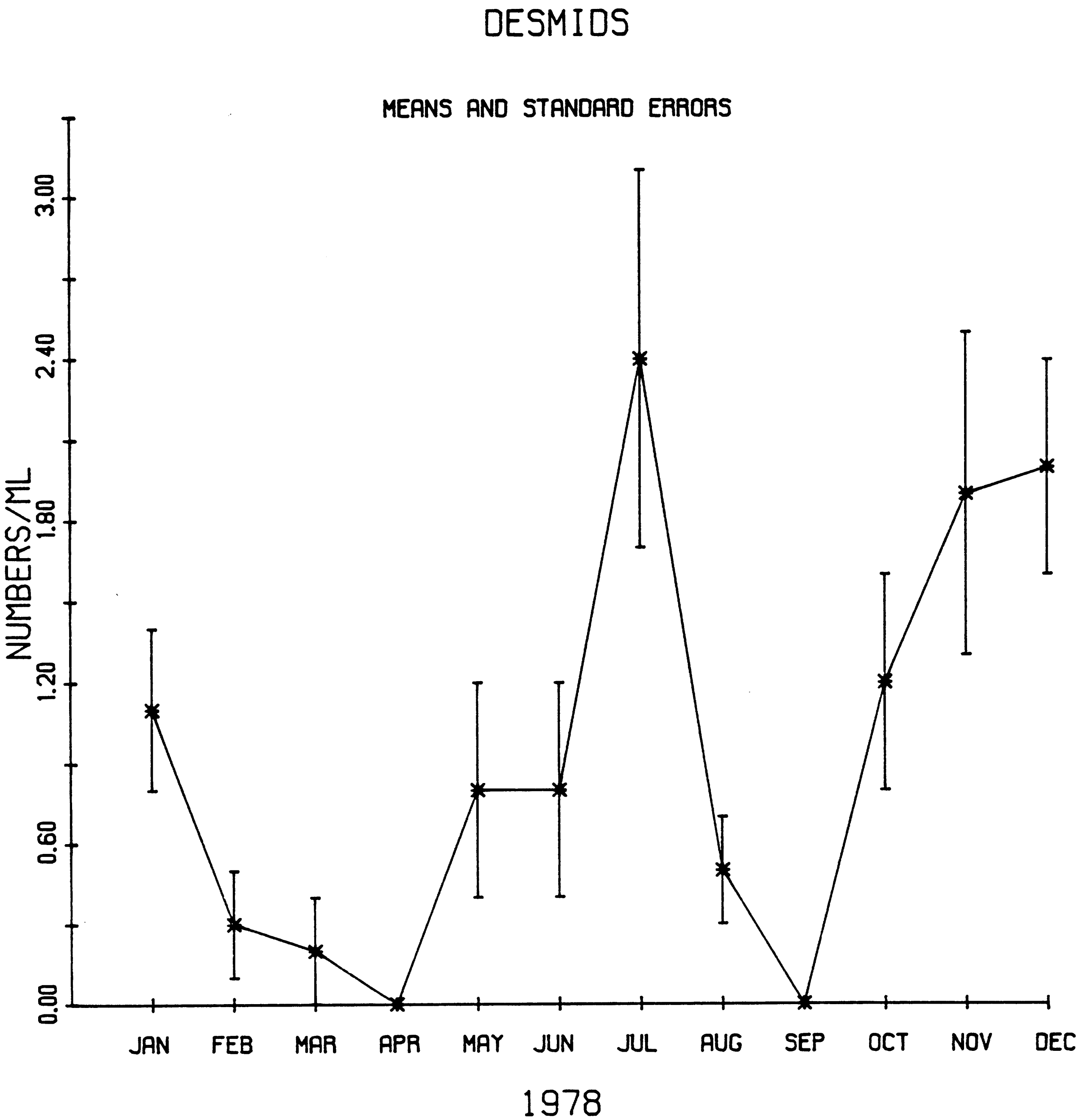

FIG. 9. Variation of desmid numbers during 1978.

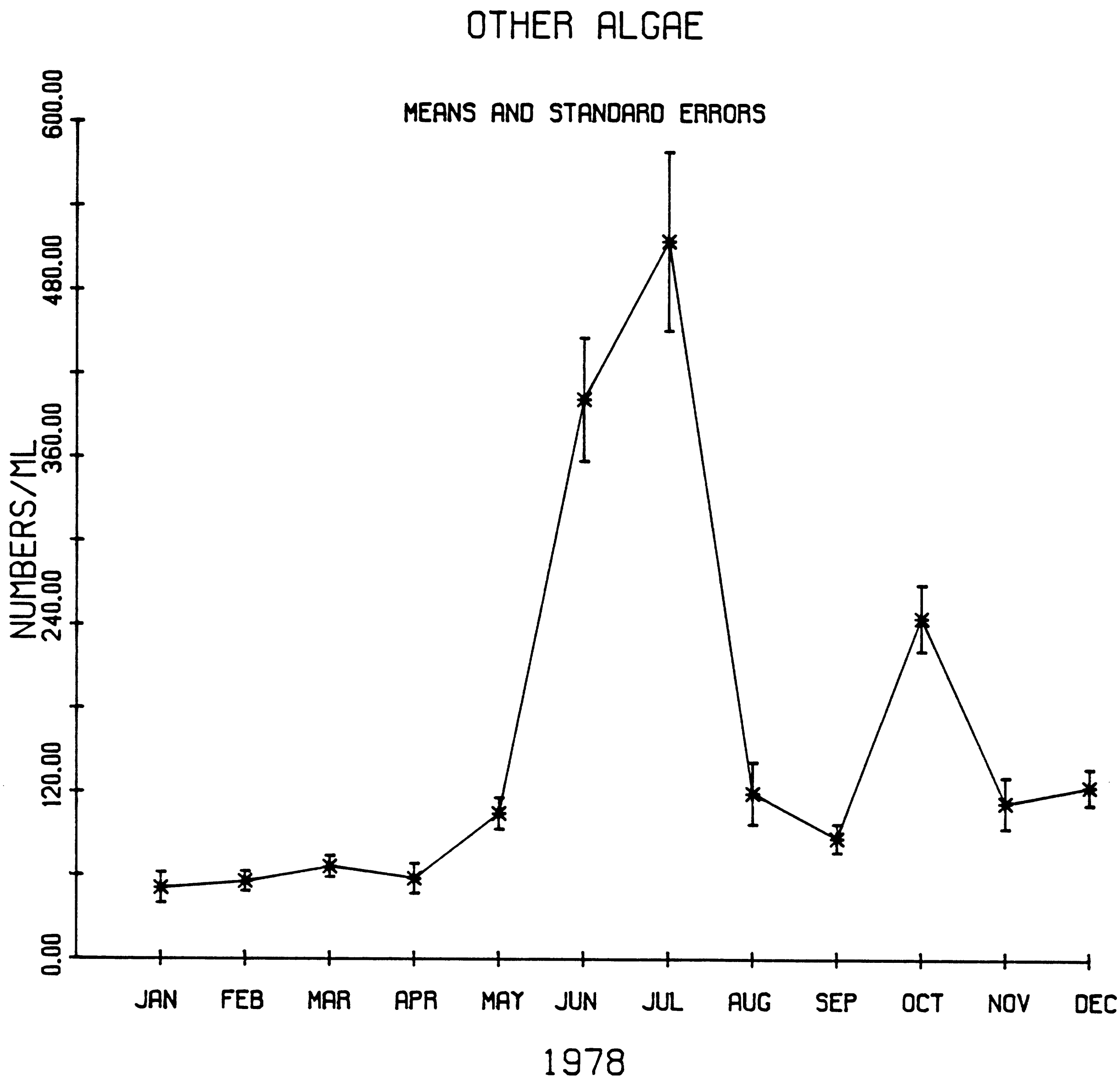

FIG. 10. Variation of other algae during 1978.

TABLE 8. Monthly variation of flagellated algae during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	110.(18.7)			156.(44.0)
February	90.8(20.8)	252.(32.1)		109.(21.7)
March	272.(56.6)	268.(25.5)	628.(60.2)	97.5(24.6)
April	857.(190.)	351.(36.6)	1010.(116.)	435.(69.9)
May	641.(82.3)	1350.(220.)	1200.(160.)	728.(167.)
June	802.(148.)	633.(70.5)	235.(30.6)	2838.(275.)
July	561.(94.6)	452.(31.6)	267.(33.9)	395.(77.7)
August	504.(56.7)	482.(86.8)	376.(31.9)	191.(18.9)
September	587.(71.6)	426.(70.3)	302.(57.8)	75.7(11.5)
October	696.(85.4)	559.(91.7)	550.(91.8)	108.(15.9)
November	417.(51.9)	524.(47.6)	754.(156.)	52.0(12.4)
December	368.(59.9)	415.(84.2)	78.9(19.3)	261.(88.0)
Yearly Mean	527.(69.0)	485.(89.0)	540.(114.)	454.(68.9)

* Mean is followed by the standard error.

Total phytoplankton abundance reached peaks in June, October, and December (Table 13 and Figure 11). The maximum was in June and corresponded with a maxi- mum of flagellated algae. The high population peaks were also encountered in October and December after isothermal conditions resumed. The extended high abundance in June and July correlated with the occurrence of an upwelling. A reduction in mean abundance was seen between the 1978 samples and those of 1975 and 1976, but there was an increase in the 1978 samples as compared to those of 1977.

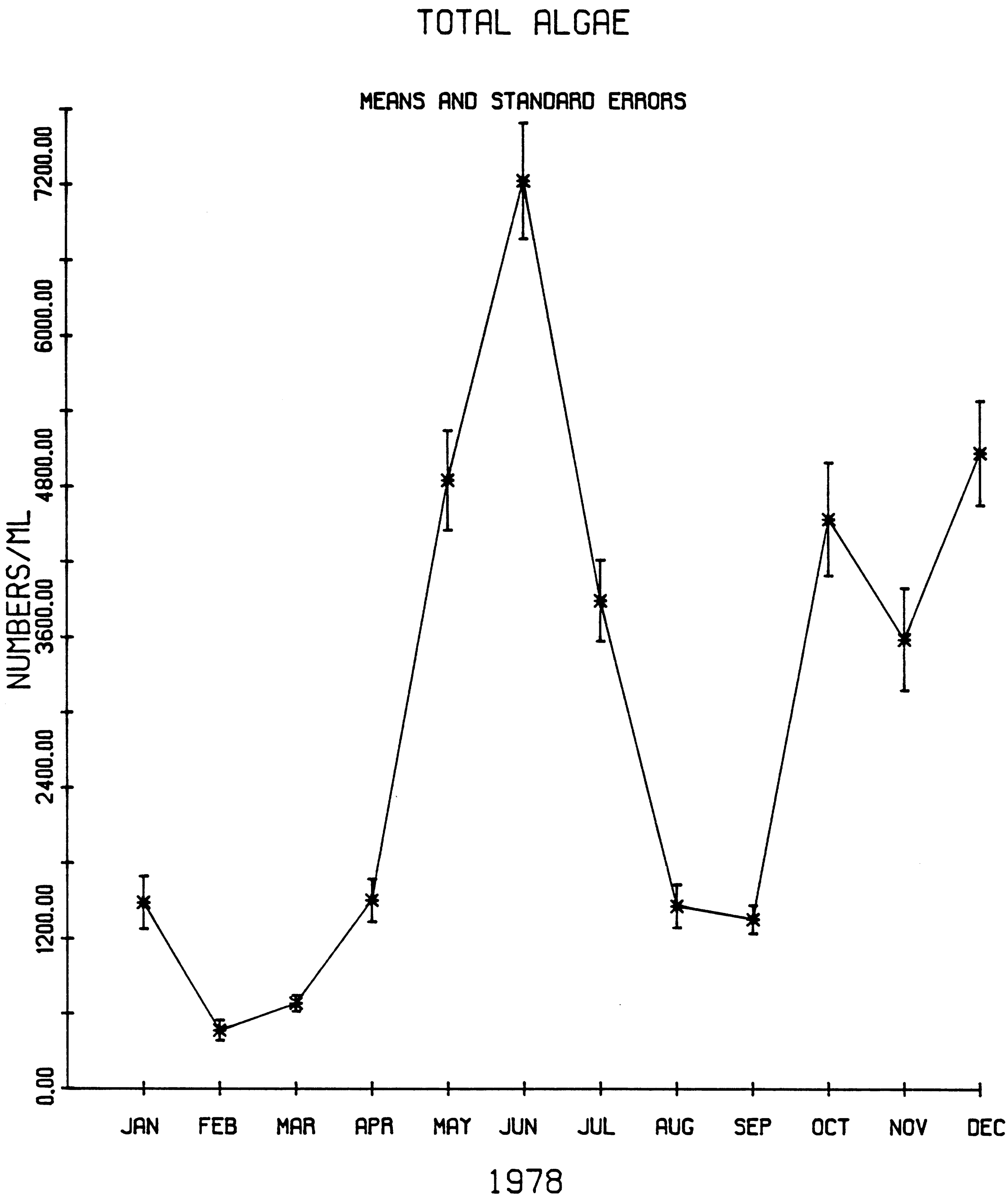

FIG. 11. Variation of total algae during 1978.

TABLE 9. Monthly variation of centric diatoms during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	1810.(191.)			310.(46.7)
February	1040.(130.)	560.(45.0)		125.(12.8)
March	1290.(111.)	807.(56.8)	463.(57.7)	423.(37.8)
April	2550.(427.)	930.(51.1)	779.(83.9)	592.(74.5)
May	1190.(170.)	1400.(189.)	139.(23.1)	1797.(167.)
June	817.(64.3)	212.(18.3)	451.(91.5)	1448.(140.)
July	914.(108.)	3370.(361.)	967.(65.9)	1101.(99.5)
August	102.(23.9)	272.(25.9)	175.(12.0)	197.(29.8)
September	69.2(8.3)	1060.(157.)	183.(14.8)	225.(40.5)
October	286.(21.2)	644.(50.9)	140.(18.1)	904.(88.7)
November	404.(64.5)	1090.(69.4)	194.(24.2)	195.(21.3)
December	1700.(132.)	503.(58.8)	165.(18.5)	160.(9.63)
Yearly Mean	945.(224.)	1050.(249.)	366.(93.7)	623.(64.0)

* Mean is followed by the standard error.

The major change observed between 1978 and 1975, 1976, and 1977 was a continuous increase in the abundance of coccoid blue-green algae.

Monthly Variations of Phytoplankton Community Structure

Occurrences of Dominant and Co-dominant forms --

Any form constituting 10% or more of the total population in a sample was considered dominant. The frequency of these dominant forms occurring in the

TABLE 10. Monthly variation of pennate diatoms during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January		991.(186.)		598.(79.0)
February	1640.(196.)	265.(43.0)		62.2(8.27)
March	1340.(146.)	329.(46.3)	1210.(90.6)	41.7(4.68)
April	1160.(306.)	1340.(123.)	1710.(187.)	226.(37.1)
May	3040.(278.)	864.(158.)	383.(45.0)	1909.(162.)
June	1220.(102.)	332.(29.9)	743.(129.)	1751.(134.)
July	90.8(12.8)	2900.(459.)	487.(44.8)	1448.(160.)
August	84.8(16.8)	1250.(207.)	73.2(10.1)	514.(71.1)
September	270.(52.7)	1920.(411.)	146.(15.5)	120.(23.2)
October	295.(34.6)	498.(36.6)	822.(45.2)	570.(63.1)
November	501.(74.2)	824.(100.)	724.(100.)	963.(107.)
December	333.(43.4)	1320.(148)	548.(50.2)	572.(45.5)
Yearly Mean	907.(271.)	1070.(220.)	685.(155.)	731.(74.6)

* Mean is followed by the standard error.

monthly samples can be used as an indication of the spatial and temporal distribution among the dominant forms in the system from which the entrainment sample is taken. A comparison of these monthly frequencies for the years in which the plant has been in operation can reveal whether any change has occurred in the distribution of these species during the period. Since many forms appeared relatively infrequently as dominant forms, they were excluded from consideration. If they were included, the resulting complexity could obscure the existing patterns. For this reason, only those forms which were

TABLE 11. Monthly variation of desmids during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	0.0(0.0)			1.05(.318)
February	0.8(0.5)	.283(.191)		.275(.207)
March	0.8(0.5)	.417(.298)	.142(.142)	.208(.215)
April	1.2(1.2)	.825(.592)	.275(.275)	0.0(0.0)
May	3.0(0.0)	1.65(.642)	1.52(.583)	.833(.435)
June	2.5(0.9)	.142(.142)	1.25(.580)	.825(.431)
July	2.2(1.2)	1.25(.843)	1.47(.325)	2.38(.696)
August	0.4(0.2)	.550(.371)	1.11(.587)	.511(.225)
September	0.3(0.3)	.275(.275)	.0667(.0667)	.022(.022)
October	0.8(0.4)	0.0(0.0)	0.0(0.0)	1.20(.439)
November	0.5(0.3)	0.0(0.0)	.825(.431)	1.94(.561)
December	0.0(0.0)	.417(.298)	1.38(.604)	1.98(.397)
Yearly Mean	1.14(.298)	.484(.150)	.804(.197)	.935(.329)

* Mean is followed by the standard error.

dominant in at least 50% of the total monthly samples were examined. The monthly comparisons among the years were made for March to December, when complete data from 1975 to 1978 were available.

In March, *Tabellaria fenestrata* v. *intermedia* and centric diatoms were dominant in 1975; *Cyclotella stelligeria* and flagellates were dominant in 1976; flagellates, *Fragillaria crotonensis*, and *Synedra filiformis* were dominant in 1977; and *Stephanodiscus* sp. were dominant in 1978 (Table 14). During April, the dominant forms were flagellates and *Cyclotella stelligera* in 1975;

TABLE 12. Monthly variation of other algae during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	62.4(18.1)			50.8(11.2)
February	7.03(3.2)	58.3(30.4)		55.6(7.19)
March	29.4(4.4)	39.9(5.93)	16.7(5.49)	66.2(7.79)
April	70.0(16.9)	91.1(42.8)	167.(20.8)	57.6(10.9)
May	84.0(17.2)	148.(27.8)	55.6(10.5)	104.(11.3)
June	148.(29.0)	104.(12.1)	37.9(7.65)	401.(44.2)
July	480.(57.1)	361.(52.3)	193.(22.0)	514.(63.8)
August	55.0(22.1)	192.(19.8)	206.(26.7)	119.(22.3)
September	31.6(6.2)	481.(54.7)	62.0(7.15)	86.6(10.3)
October	44.0(5.0)	166.(23.7)	183.(21.4)	245.(23.7)
November	65.7(13.0)	84.7(14.5)	119.(15.6)	112.(18.5)
December	71.0(13.1)	42.0(7.67)	63.4(15.1)	124.(13.0)
Yearly Mean	98.7(39.7)	153.(39.5)	110.(22.6)	161.(20.3)

* Mean is followed by the standard error.

Fragilaria crotonensis and *Asterionella formosa* in 1976; flagellates, *Fragilaria crotonensis*, chrysophycean flagellates, and *Synedra filiformis* in 1977; and chrysophycean flagellates and *Stephanodiscus* sp. in 1978 (Table 15). The dominant forms for May were *Tabellaria fenestrata v. intermedia* in 1975, flagellates in 1976, flagellates in 1977, and *Melosira granulata* in 1978 (Table 16). In June, the dominate forms were flagellates and *Tabellaria fenestrata v. intermedia* in 1975, flagellates and *Dinobryon divergens* in 1976, *Fragilaria crotonensis* in 1977, and chrysophycean flagellates in 1978

TABLE 13. Monthly variation of total algae during 1975, 1976, 1977, and 1978 (cells/mL).

Month	1975*	1976*	1977*	1978*
January	3530.(429.)			1486.(210.)
February	2970.(318.)	1410.(147.)		465.(81.8)
March	3340.(421.)	1840.(182.)	2500.(206.)	681.(63.9)
April	5020.(816.)	2990.(200.)	3890.(336.)	1503.(170.)
May	5800.(413.)	4520.(396.)	1860.(214.)	4843.(396.)
June	3710.(302.)	1550.(132.)	1650.(249.)	7223.(461.)
July	4200.(243.)	7940.(836.)	2280.(156.)	3884.(321.)
August	1270.(92.8)	3140.(292.)	2170.(296.)	1456.(172.)
September	2380.(208.)	5050.(675.)	1690.(140.)	1351.(113.)
October	2490.(286.)	2720.(291.)	2680.(285.)	4533.(450.)
November	2150.(259.)	3090.(237.)	3210.(428.)	3576.(407.)
December	2790.(170.)	2870.(312.)	1840.(189.)	5058.(414.)
Yearly Mean	3280.(399.)	3390.(519.)	2380.(228.)	3005.(272.)

* Mean is followed by the standard error.

(Table 17). In July, Cyclotella stelligera, Dictyosphaerium pullchelum, and Gloeocystis sp. were dominant in 1975; no forms were dominant in more than 50% of the total samples in 1976; Cyclotella sp., Cyclotella comensis, and Fragilaria crotonensis were dominant in 1977; and Fragilaria crotonensis and Scenedesmus bicellularis were dominant in 1978 (Table 18). In August, Anacystis incerta and Chromulina parvula were dominant in 1975, Fragilaria crotonensis was dominant in 1976, Anacystic incerta and flagellates were dominant in 1977, and Fragilaria crotonensis was dominant in 1978 (Table 19).

TABLE 14. Occurrence of dominant forms in March 1975, 1976, 1977, and 1978.

Form	Occurrences 1975	1976	1977	1978
Anacystis incerta	0	5	0	2
Cyclotella stelligera	4	6	0	0
Flagellates	1	9	9	3
Gomphosphaeria lacustris	2	3	2	0
Cyclotella sp.	0	3	0	0
Asterionella formosa	0	1	0	0
Blue-green, unknown cells	0	1	0	0
Tabellaria fenestrata var. *intermedia*	9	0	0	0
Centric diatoms, unknown	6	0	0	4
Stephandiscus sp.	3	0	0	11
Fragilaria crotonensis	1	0	11	0
Chrysophycean flagellate spp.	0	0	2	0
Synedra filiformis	0	0	11	0
Stephanodiscus #5	0	0	0	5
Number of samples	9	12	12	12

In September, *Anacystis incerta* and flagellates predominated in 1975, *Fragilaria crotonensis* did so in 1976, *Anacystic incerta* and flagellates did so in 1977, and *Anacystis incerta* did so in 1978 (Table 20). In October, *Anacystis incerta*, flagellates, and *Gomphosphaeria lacustris* were dominant in 1975; flagellates were dominant in 1976; *Anacystis incerta*, *Fragilaria*

TABLE 15. Occurrence of dominant forms in April 1975, 1976, 1977, and 1978.

Form	Occurrences 1975	1976	1977	1978
Cyclotella stelligera	5	1	0	0
Flagellates	6	0	6	5
Fragilaria crotonensis	1	6	9	0
Gomphosphaeria lacustris	1	0	0	0
Stephanodiscus minutus	1	0	0	0
Stephanodiscus tenuis	2	0	0	0
Stephanodiscus #5	0	0	0	3
Anacystis incerta	1	3	1	3
Asterionella formosa	0	12	0	0
Rhizosolenia gracilis	0	3	0	0
Green colony, unknown	0	1	0	0
Fragilaria intermedia v. *fallax*	0	1	0	0
Chrysophycean flagellate spp.	0	0	6	9
Synedra filiformis	0	0	11	0
Synedra ostenfeldii	0	0	1	0
Stephandiscus sp.	0	0	0	10
Number of samples	9	12	12	12

crotonensis, and flagellates were dominant in 1977; and *Anacystis incerta*, *Gomphosphaeria lacustris*, and *Melosira granulata* were dominant in 1978 (Table 21). During November, the dominant forms were flagellates, *Anacystis*

TABLE 16. Occurrence of dominant forms in May 1975, 1976, 1977, and 1978.

Form	Occurrences 1975	1976	1977	1978
Anacystis incerta	4	0	0	0
Fragilaria crotonensis	4	0	2	4
Tabellaria fenestrata var. *intermedia*	5	0	1	0
Flagellates	4	11	9	1
Ochromonas sp.	0	5	0	0
Centric diatom, unknown	0	1	0	0
Oscillatoria limnetica	0	1	0	0
Rhizosolenia gracilis	0	1	0	0
Cyclotella sp.	0	1	0	0
Asterionella formosa	0	1	0	3
Stephanodiscus subtilis	0	1	0	0
Stephanodiscus sp.	0	0	0	1
Gomphosphaeria lacustris	0	0	1	0
Chrysophycean flagellate spp.	0	0	5	1
Synura sp.	0	0	1	0
Melosira granulata	0	0	0	6
Number of samples	9	12	12	12

incerta, *Fragilaria crotonensis*, and *Cyclotella comensis* in 1975; flagellates and *Cyclotella* sp. in 1976; flagellates, *Anacystis incerta*, and *Gomphosphaeria lacustris* in 1977; and *Anacystis incerta*, *Fragilaria crotonensis*, and

TABLE 17. Occurrence of dominant forms in June 1975, 1976, 1977, and 1978.

Form	Occurrences			
	1975	1976	1977	1978
Flagellates	9	11	2	0
Tabellaria fenestrata var. *intermedia*	10	0	5	0
Fragilaria capucina	1	0	0	0
Stephanodiscus tenuis	2	0	0	0
Oscillatoria limnetica	2	0	0	0
Anacystis incerta	1	0	1	2
Gomphosphaeria lacustris	2	1	1	2
Fragilaria crotonensis	2	0	8	1
Chlorella sp.	0	1	0	0
Diatoma tenue var. *elongatum*	0	1	0	0
Dinobryon bavaricum	0	5	0	0
Dinobryon divergens	0	9	0	0
Chrysophycean flagellate spp.	0	0	2	12
Merismopedia elegans	0	0	1	0
Cyclotella stelligera	0	0	1	0
Number of samples	12	12	12	12

Gomphosphaeria lacustris in 1978 (Table 22). In the month of December, centric diatoms and *Cyclotella stelligera* were dominant in 1975; *Fragilaria crotonensis* and flagellates were dominant in 1976; *Anacystis incerta*, *Gomphosphaeria lacustris*, and *Tabellaria fenestrata* *v.* *intermedia* were dominant in 1977; and

TABLE 18. Occurrence of dominant forms in July 1975, 1976, 1977, and 1978.

Form	Occurrences 1975	1976	1977	1978
Anacystis incerta	2	0	0	3
Cyclotella sp.	2	0	8	0
Cyclotella stelligera	9	0	0	0
Dictyosphaerium pulchellum	10	0	0	0
Gloeocystis sp.	9	1	0	0
Merismopedia tennuissima	1	0	0	0
Gomphosphaeria lacustris	1	0	1	2
Flagellates	4	0	3	5
Green coccoid, unknown	1	0	0	0
Gloeocystis planctonica	1	0	0	1
Stephanodiscus sp.	0	1	0	0
Centric diatom, unknown	0	5	0	0
Melosira granulata	0	0	0	1
Fragilaria crotonensis	0	5	10	11
Sphaerocystis sp.	0	1	0	0
Tabellaria fenestrata var. *intermedia*	0	0	0	2
Stephanodiscus subtilis	0	1	0	0
Cyclotella comensis	0	0	12	0
Scenedesmus bicellularis	0	0	0	6
Number of samples	12	12	12	18

TABLE 19. Occurrence of dominant forms in August 1975, 1976, 1977, and 1978.

Form	Occurrences 1975	1976	1977	1978
Anacystis incerta	8	3	10	3
Chromulina parvula	9	0	0	0
Gomphosphaeria lacustris	3	2	0	3
Cyclotella stelligera	4	0	0	0
Gloeocystis sp.	5	4	0	0
Flagellates	3	5	6	4
Synura sp.	1	0	0	0
Fragilaria crotonensis	0	11	0	18
Gloeocystis planctonica	0	1	0	1
Anacystis cyanea	0	0	0	1
Chrysophycean flagellate sp.	0	1	5	0
Anacystis thermalis	0	0	5	0
Tabellaria fenestrata var. *intermedia*	0	0	0	1
Crucigenia rectangularis	0	0	4	0
Cyclotella sp.	0	0	1	0
Anabaena flos-aquae	0	0	0	6
Number of samples	12	12	12	18

Gomphosphaeria lacustris and *Anacystis incerta* were dominant in 1978 (Table 23).

No consistent trend of change in dominant species was observed in the monthly comparisons during the years of 1975, 1976, 1977, and 1978. However,

TABLE 20. Occurrence of dominant forms in September 1975, 1976, 1977, and 1978.

	Occurrences			
Form	1975	1976	1977	1978
Anacystis incerta	11	4	12	18
Fragilaria crotonensis	2	8	0	0
Gomphosphaeria lacustris	5	0	2	1
Flagellates	6	1	6	1
Anacystis thermalis	4	0	0	0
Melosira granulata	0	0	0	8
Ochromonas sp.	2	0	0	0
Gloeocystis sp.	0	5	0	0
Botryococcus braunii	0	0	0	1
Sphaerocystis sp.	0	1	0	0
Gloeocystis planctonica	0	0	0	1
Chrysophycean flagellate sp.	0	1	0	0
Anacystis cyanea	0	0	0	1
Number of samples	12	12	12	18

if the data are prepared in the form of total annual occurrence for the dominant species following the trophic table compiled by Tarapchak and Stoermer (1976) using the diatom species as shown in Table 24, certain patterns emerge (Table 25). A continuous decrease from 1975 to 1978 in occurrences of mesotrophic species not tolerant of nutrient enrichment can be noted; such occurrences range from 31 in 1975 to 7 in 1976, 1 in 1977, and 0 in 1978.

TABLE 21. Occurrence of dominant forms in October 1975, 1976, 1977, and 1978.

Form	Occurrences 1975	1976	1977	1978
Anacystis incerta	10	5	10	16
Fragilaria crotonensis	1	2	10	0
Flagellates	8	9	8	0
Gomphosphaeria lacustris	6	2	3	13
Ochromonas sp.	3	0	0	0
Gomphosphaeria sp.	0	0	0	1
Cyclotella comensis	0	2	0	0
Gloeocystis planctonica	0	1	0	0
Melosira granulata	0	0	0	13
Chrysophycean flagellate sp.	0	2	0	0
Gloeocystis sp.	0	1	1	0
Anacystis cyanea	0	0	1	0
Tabellaria fenestrata var. *intermedia*	0	0	1	0
Number of samples	10	12	12	18

On the other hand, there is an increase from 1975 to 1977 in occurrences of mesotrophic species which are tolerant of moderate nutrient enrichment, 41 in 1975, 65 in 1976, and 94 in 1977. However, in 1978 there was a decrease to 57 occurrences (Table 26).

Some marked changes have been observed in entrainment assemblages (Table 27): 1) a continuous large increase in occurrence and in abundance of

TABLE 22. Occurrence of dominant forms in November 1975, 1976, 1977, and 1978.

Form	Occurrences 1975	1976	1977	1978
Flagellates	7	8	9	0
Anacystis incerta	7	5	10	11
Chrysophycean flagellate sp.	0	3	3	0
Fragilaria crotonensis	6	4	4	7
Agmenellum quadruplicatum	1	0	1	1
Gomphosphaeria lacustris	4	0	8	9
Centric diatom, unknown	2	0	0	0
Stephanodiscus sp.	1	0	0	0
Cyclotella comensis	10	0	0	0
Cyclotella sp.	0	7	0	0
Tabellaria fenestrata var. intermedia	0	1	0	0
Asterionella formosa	0	2	2	0
Gloeocystis sp.	0	1	0	0
Number of samples	12	12	12	12

the blue-green alga Anacystis incerta in 1978; 2) a significant increase in occurrence of Gomphosphaeria lacustris from 1976 to 1978; 3) a decrease in occurrence of flagellates in 1978 compared to the previous year; and 4) an increase in occurrence of dominant blue-green algae in 1978. The mechanisms which cause these changes are presently unknown and, from the information available, it is difficult to offer a good explanation; nevertheless, a further

TABLE 23. Occurrence of dominant forms in December 1975, 1976, 1977, and 1978.

Form	Occurrences			
	1975	1976	1977	1978
Centric diatom, unknown	9	0	0	0
Cyclotella stelligera	9	0	0	0
Ochromonas sp.	3	0	0	0
Sphaerocystis schroeteri	1	0	0	0
Gomphosphaeria lacustris	1	1	7	17
Stephanodiscus minutus	1	0	0	0
Stephanodiscus sp.	1	0	0	0
Cyclotella comensis	1	1	0	0
Cyclotella sp.	1	0	0	0
Anacystis incerta	1	3	12	16
Fragilaria crotonensis	0	12	0	0
Flagellates	0	6	0	2
Fragilaria capucina var. *lanceolata*	0	1	0	0
Anabaena flos-aquae	0	1	1	0
Gloeocystis planctonica	0	2	0	0
Tabellaria fenestrata var. *intermedia*	0	0	6	0
Agmenellum quadruplicatum	0	0	1	1
Anacystis thermalis	0	0	2	0
Number of samples	11	12	12	18

TABLE 24. Apparent trophic preference and abundance of selected diatoms in Lake Michigan.

Selected Diatoms	Trophic Preference O	M1	M2	E	EI
Cyclotella comta (Ehr.) Kütz.	P	M	P		
Cyclotella operculata (Ag.) Kütz.	M				
Cyclotella ocellata Pant.	M	P			
Cyclotella kuetzingiana Thwaites	P	M	P		
Cyclotella stelligeria Cl. n. Grun.	P	M	P		
Melosira distans (Ehr.) Kütz.	M				
Melosira distans var. *alipigena* Grun.					M
Melosira islandica O. Mull.	P	M	P		
Tabellaria fenestrata (Lyngb.) Kütz.		P	M	P	
Tabellaria flocculosa (Roth) Kütz.		M	P		
Rhizosolenia eriensis H. L. Smith	P	M	P		
Stephanodiscus transilvanicus Pant.	P	M			
Synedra ulna var. *chaseana* Thomas	P	M			
Cyclotella michiganiana Skv.	P	M	P		
Asterionella formosa Hass.		P	M	P	
Fragilaria crotonensis Kitton		P	M	P	
Stephanodiscus alpinus Hust. *ex* Huber-Pestalozzi		P	M	P	
Stephanodiscus minutus Grun. *ex* Cleve and Moll.				P	M
Stephanodiscus niagarae Ehr.			P	M	
Stephanodiscus hantzschii Grun.			P	M	

Symbols: O, oligotrophic; M1, mesotrophic but intolerant of nutrient enrichment; M2, mesotrophic and tolerant of moderate nutrient enrichment; E, eutrophic; EI, recently introduced eutrophic species; P, presence of species; and M, apparent maximum abundance of the species.

References: Holland (1968, 1969); Stoermer and Yang (1969, 1970); Holland and Beeton (1972). (Courtesy to Tarapchak and Stoermer).

TABLE 24. (continued).

Selected Diatoms	Trophic Preference O	M1	M2	E	EI
Synedra delicatissima Lewis		P	M	P	
Synedra ulna v. *danica* (Kütz.) Grun.		P	M	P	
Synedra ostenfeldii (Krieger) A. Cleve		P	M	P	
Synedra filiformis Grun.		P	M	P	
Amphipleura pellucida (Kütz.)			P	M	P
Melosira granulata (Ehr.) Ralfs			P	M	
Melosira granulata var. *angustissima* Mull.			P	M	
Fragilaria capucina Desm.			P	M	
Fragilaria capucina var. *mesolepta* (Rabh.) Grunow			P	M	
Fragilaria construens (Ehr.) Grunow			P	M	
Fragilaria intermedia Grun.			P	M	
Stephanodiscus tenuis Hust.				P	M
Asterionella bleakeleyi Wm. Smith				P	M
Diatoma tenue v. *elongatum* Lyng.				P	M
Stephanodiscus binderanus (Kütz.) Krieger				P	M
Stephanodiscus subtilis (Van Goor) A. Cleve				P	M
Nitzschia dissipata (Kutz.) Grun.				M	P
Coscinodiscus subsalsa Juhl.-Dannf.					M

Symbols: O, oligotrophic; M1, mesotrophic but intolerant of nutrient enrichment; M2, mesotrophic and tolerant of moderate nutrient enrichment; E, eutrophic; EI, recently introduced eutrophic species; P, presence of species; and M, apparent maximum abundance of the species.

References: Holland (1968, 1969); Stoermer and Yang (1969, 1970); Holland and Beeton (1972). (Courtesy to Tarapchak and Stoermer).

TABLE 25. The annual occurrence of selected dominant diatom forms in 1975, 1976, 1977, and 1978. (Refer to Table 24 for definition of symbols M1, M2, and E).

	1975	1976	1977	1978
Stephanodiscus minutus (E)	2	0	0	0
Fragilaria capucina (E)	1	1	0	0
Stephanodiscus tenuis (E)	4	1	0	0
Stephanodiscus subtilis (E)	0	2	0	0
Diatoma tenue v. *elongatum* (E)	0	1	0	0
Fragilaria crotonensis (M2)	17	48	56	51
Tabellaria fenestrata var. *intermedia* (M2)	24	1	14	3
Synedra filiformis (M2)	0	0	22	0
Asterionella formosa (M2)	0	16	2	3
Cyclotella stelligera (M1)	31	7	1	0
Cyclotella sp.	3	12	9	0
Cyclotella comensis	11	3	12	0

TABLE 26. The annual occurrence of dominant diatom forms with respect to each trophic level for 1975, 1976, 1977, and 1978. (Refer to Table 24 for definition of symbols M1, M2, and E)

	1975	1976	1977	1978
Mesotrophic, intolerant of nutrient enrichment	31	7	1	0
Mesotrophic, tolerant of moderate nutrient enrichment	41	65	94	57
Eutrophic	7	5	0	0

TABLE 27. The annual occurrence of dominant blue-green algae and flagellates in 1975, 1976, 1977, and 1978.

	1975	1976	1977	1978
Flagellates	41	49	56	21
Anacystis incerta	45	28	56	74
Chrysophycean flagellate	2	4	23	22
Gomphosphaeria lacustris	25	8	25	47
Dominant blue-green	72	40	104	143

study of these species may yield considerable insight in determining the factors influencing these changes.

Numbers of Forms, Diversity, and Redundancy --

When working with complex and variable assemblages of phytoplankton such as those appearing in entrainment samples from the nearshore of Lake Michigan, it is advantageous to use some quantitative measure of the distribution of populations within the various assemblages. Such measures can furnish information for assessing changes in community structure. The quantitative measures employed in this study are the number of species, diversity index, and redundancy.

The diversity index is calculated using the formula presented by Wilhm and Dorris (1968):

$$\bar{d} = - \sum_{i=1}^{S} (n_i/n) \log_2 (n_i/n)$$

where S is the number of species, n is the total number of phytoplankton in cells/mL, and n_i is the number of phytoplankton of the ith species. Since not all forms encountered can be identified to the species level, the diversity index presented may differ somewhat from the true diversity measure.

Redundancy is a measure of the dominance of one or a few species within a population assemblage. As presented by Wilhm and Dorris (1968), it is:

$$r = \frac{\bar{d}max - \bar{d}}{\bar{d}max - \bar{d}min}$$

where $\bar{d}$ is the diversity of a community as calculated above, $\bar{d}max$ is the maximum diversity for the community, and $\bar{d}min$ is the minimum diversity for the community. $\bar{d}max$ and $\bar{d}min$ are computed as follows:

$$\bar{d}max = (1/n)(\log_2 n! - S\log_2 [n/S]!)$$

$$\bar{d}min = (1/n)(\log_2 n! - S\log_2 [n-(S-1)]!)$$

The possible values of r vary between 0 and 1. When an r equals 0, it indicates that all the species encountered in a community have the same abundance, whereas when an r equals 1, it implies that one species dominates a community. As shown in the formula, this value is derived from the measure of species number, abundance, and diversity.

The number of forms in the 1978 entrainment samples showed a bimodal variation, with its primary peak in June and its secondary peak in October (Table 28 and Figure 12). The number of forms varies from 40 to 86; the minimum and maximum number of forms correspond with the months of March and June, respectively. The largest changes occurred between April and May.

Species number fluctuations have long been an important issue. Many theories attempt to explain this phenomenon. The one offering the simplest and most plausible explanation for this entrainment system was proposed by Moss (1973) who explained that different species begin to divide at different times of the year dependent on their specific requirements for light, temperature, and nutrient types and levels. Most of these species are probably present in at least very small numbers throughout the year, and from these inocula larger populations can develop. After growth of a large population, decline occurs as the number of cells returns to the inoculum level. Population size depends on the balance between growth and concomitant loss by sinking, parasitism, and

TABLE 28. Comparison of the number of forms of phytoplankton for 1975, 1976, 1977, and 1978. Standard errors are included in parentheses.

Month	1975 Replicates	1975 Forms	1976 Replicates	1976 Forms	1977 Replicates	1977 Forms	1978 Replicates	1978 Forms
January	--1	--1	11	59.4(2.79)	--1	--1	11	62.9(2.47)
February	--1	51.1(1.90)	12	57.3(1.64)	--1	--1	12	48.9(1.01)
March	9	51.7(1.89)	12	59.3(1.59)	12	52.9(2.36)	12	40.3(1.16)
April	9	48.3(1.38)	12	56.1(1.43)	12	55.5(3.37)	12	55.1(3.24)
May	9	47.4(1.78)	12	60.3(2.84)	12	46.4(2.91)	12	81.9(2.07)
June	12	49.2(1.77)	12	65.8(1.77)	12	64.1(3.59)	12	85.3(4.17)
July	12	51.6(.892)	12	87.3(3.78)	12	57.7(2.64)	18	68.7(2.73)
August	12	44.5(2.32)	12	53.4(3.31)	12	46.9(2.26)	18	49.9(1.73)
September	10	44.1(3.12)	12	84.8(4.30)	12	60.3(2.75)	18	67.1(2.53)
October	12	54.0(2.18)	12	58.8(2.77)	12	52.3(2.60)	18	78.2(3.02)
November	12	50.3(2.11)	12	57.2(1.74)	12	46.6(1.85)	12	72.6(3.47)
December	11	50.8(1.74)	12	56.5(1.81)	12	56.4(2.52)	13	55.1(2.19)
Yearly Mean		49.4(.969)		63.1(3.25)		53.9(1.92)		63.9(2.50)

1 Samples were not collected where dashes appear.

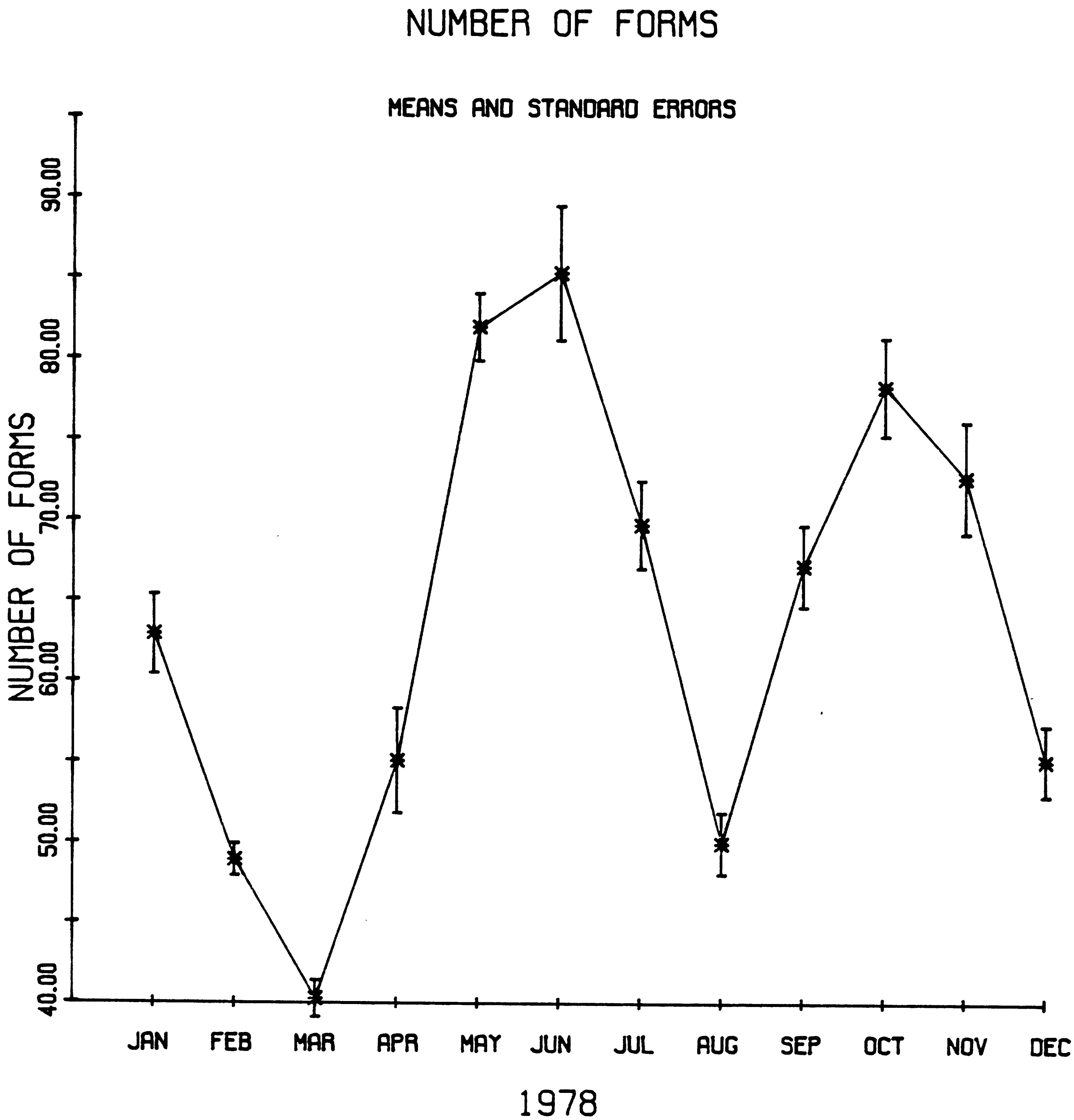

FIG. 12. Variation of number of forms during 1978.

grazing. After the peak population has been reached, there is a rapid initial decline. As some populations decline, others grow, and with time the complexity of overlap increases, leading to progressively greater diversity. This hypothesis seems to explain why the number of forms increased rapidly in April and September after an initial decline in the months of March and August. But this hypothesis alone cannot fully illustrate all the changes in the system. In part the increase in summer can be attributed to upwelling which makes available hypolimnetic nutrients, including orthophosphate and silica, which stimulate the growth of some forms (Rossmann *et al*. 1979).

The diversity index is an estimate of the structure of communities. It measures the degree to which individuals are represented in an assemblage, and is determined by the number of species and the degree of apportionment of individuals among species. For example, a high diversity index can signify (1) large numbers of species, or (2) a high degree of apportionment of individuals among species, or (3) both of the above. In 1978, diversity reached its maximum in May and its minimum in December, corresponding with the values 4.98 and 2.91, respectively (Table 29 and Figure 13). The maximum coincided with the time when the maximum number of species occurred. This phenomenon does not always occur; frequently, a large number of species does not result in a high diversity index. This is because the diversity index depends on not only the number of species but also the codominancy of many species. Therefore, it is not uncommon that a sample with a high abundance where one species is dominant has a relatively low diversity value. In fact, the cases of September 1977 and October 1978 illustrate this situation: a large number of species was encountered, but only one species, *Anacystis incerta*, was the dominant phytoplankter appearing at the time. Despite these

TABLE 29. Comparison of phytoplankton diversities for 1975, 1976, 1977, and 1978. Standard errors are included in parentheses.

Month	1975 Replicates	1975 Forms	1976 Replicates	1976 Forms	1977 Replicates	1977 Forms	1978 Replicates	1978 Forms
January	--1	--1	11	4.29(.0457)	--1	----1	11	4.54(.089)
February	9	4.35(.0473)	12	4.47(.0591)	--	----	12	4.38(.107)
March	9	4.30(.0544)	12	4.34(0.633)	12	3.85(.0680)	12	3.70(.110)
April	9	4.21(.0569)	12	4.30(.0446)	12	4.36(.0872)	12	4.24(.116)
May	9	3.76(.228)	12	4.37(.112)	12	2.98(.186)	12	4.98(.035)
June	12	4.17(.0809)	12	4.67(.0616)	12	4.62(.0836)	12	4.33(.104)
July	12	3.93(.0654)	12	5.08(.0380)	12	4.00(.0564)	18	4.87(.049)
August	12	3.58(.163)	12	3.50(.114)	12	3.29(.161)	18	4.07(.069)
September	10	3.36(.189)	12	4.92(.0973)	12	3.29(.109)	18	4.40(.149)
October	12	3.96(.138)	12	4.48(.0823)	12	4.00(.0764)	18	3.77(.112)
November	12	4.02(.119)	12	3.97(.0608)	12	3.69(.0945)	12	3.58(.112)
December	11	3.83(.09829	12	3.96(.0963)	12	3.82(.113)	18	2.91(.082)
Yearly Mean		3.95(.0924)		4.36(.124)		3.79(.159)		4.15(.095)

1 Samples were not collected where dashes appear.

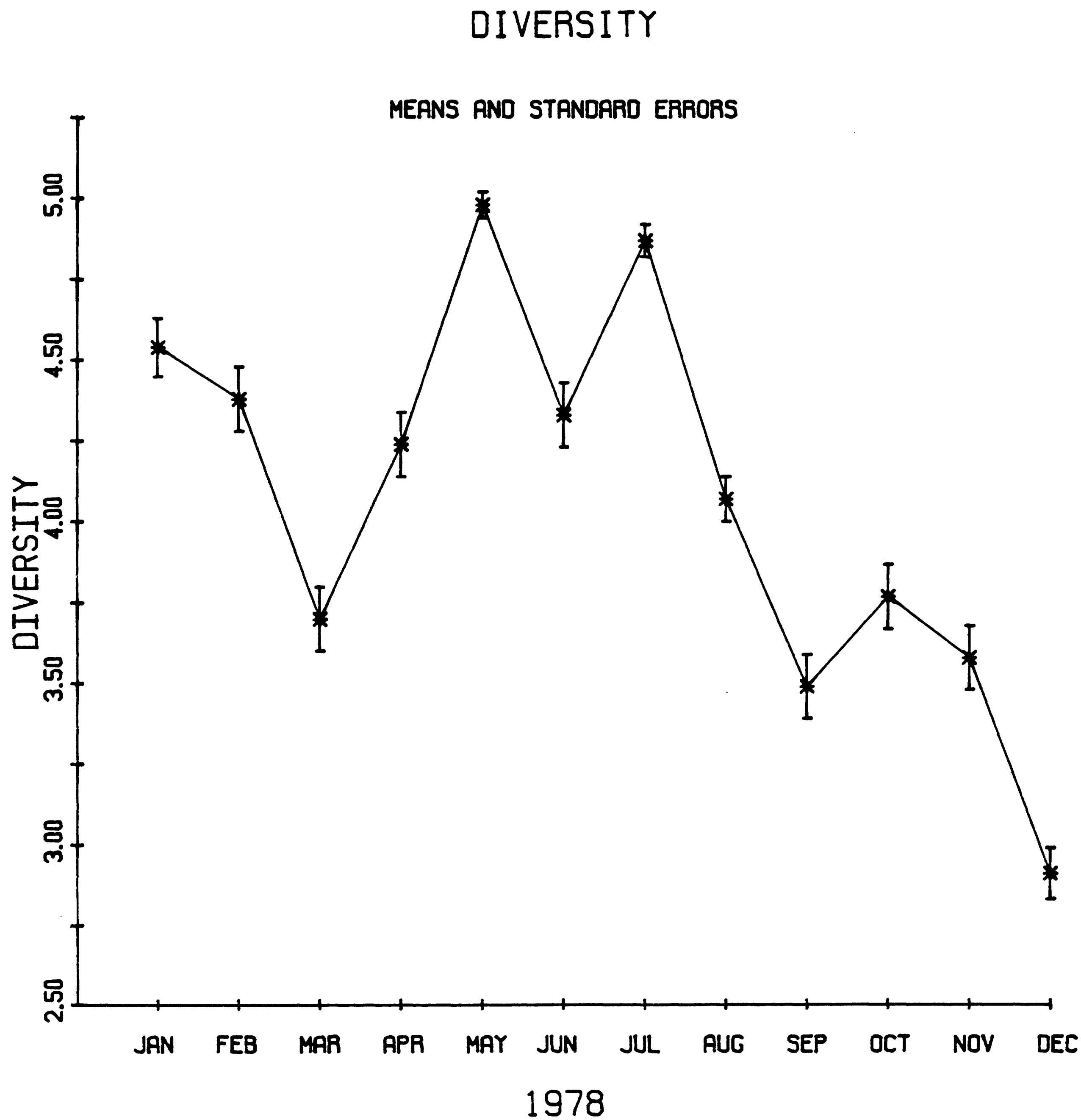

FIG. 13. Variation of diversity during 1978.

exceptions, species number has often been significantly correlated with the diversity indices (Rossmann et al. 1980). In the open lake, the diversity index normally ranges from values slightly greater than zero (in bloom situations) to values as high as 4.5 (Tarapchak and Stoermer 1976). In this system, however, the monthly mean index of the 1978 entrained samples varied from 2.91 to 4.98, with an annual mean of 4.15. According to the Margalef classification (1968), the ranges of values corresponding to trophic states are as follows: oligotrophic, >3.5; mesotrophic, 2.5 to 3.5; and eutrophic, <2.5. Considering the annual mean of diversity, this geographic region is still far from a state in which any disturbance drastically changes algal community structure and thereby reduces the diversity index significantly.

In 1978, redundancy was low in May and July and high in September, November, and December (Table 30, Figure 14). Redundancy reached maximum and minimum values in December and July, respectively. The high redundancy values in May, August, and September coincided with a community of predominantly one species; during the month of May, the species *Fragilaria crotonensis* predominated, and during August and September, the species *Anacystic incerta* predominated. The minimum redundancy in July shows the codominance of a large number of species, which may be attributed both to upwelling and to overlap of significant species during phytoplankton succession.

When the species numbers and the diversity and redundancy indices are compared annually, the number of species is high in 1976 and 1978, but low in 1975 and 1977, and the diversity index is also at its peak in 1976 and 1978. The redundancy index, however, has its maximum in 1978 and its minimum in 1976. This indicates that the 1978 phytoplankton assemblage was predominated

TABLE 30. Comparison of phytoplankton redundancies for 1975, 1976, 1977, and 1978. Standard errors are included in parentheses.

Month	1975 Replicates	1975 Forms	1976 Replicates	1976 Forms	1977 Replicates	1977 Forms	1978 Replicates	1978 Forms
January	--[1]	--[1]	11	.270(.011)	--[1]	----	11	0.238(.016)
February	9	.230(.009)	12	.231(.011)	--	----	12	0.207(0.024)
March	9	.243(.008)	12	.263(.011)	12	.329(.008)	12	0.317(0.021)
April	9	.246(0.09)	12	.260(.007)	12	.244(.006)	12	0.272(0.013)
May	9	.327(.054)	12	.259(.015)	12	.474(.030)	12	0.217(0.007)
June	12	.258(.010)	12	.223(.010)	12	.223(.011)	12	0.329(0.013)
July	12	.310(.011)	12	.210(.008)	12	.318(.012)	18	0.201(0.006)
August	12	.353(.026)	12	.393(.017)	12	.411(.034)	18	0.286(0.009)
September	10	.389(.029)	12	.227(.013)	12	.457(.022)	18	0.447(0.026)
October	12	.317(.021)	12	.322(.014)	12	.335(.015)	18	0.405(0.017)
November	12	.289(.019)	12	.322(.011)	12	.348(.019)	12	0.427(0.019)
December	11	.325(.017)	12	.322(.018)	12	.348(.019)	18	0.502(0.017)
Yearly Mean		299(.0152)		.268(.0154)		.344(.0262)		0.320(0.030)

[1] Samples were not collected where dashes appear.

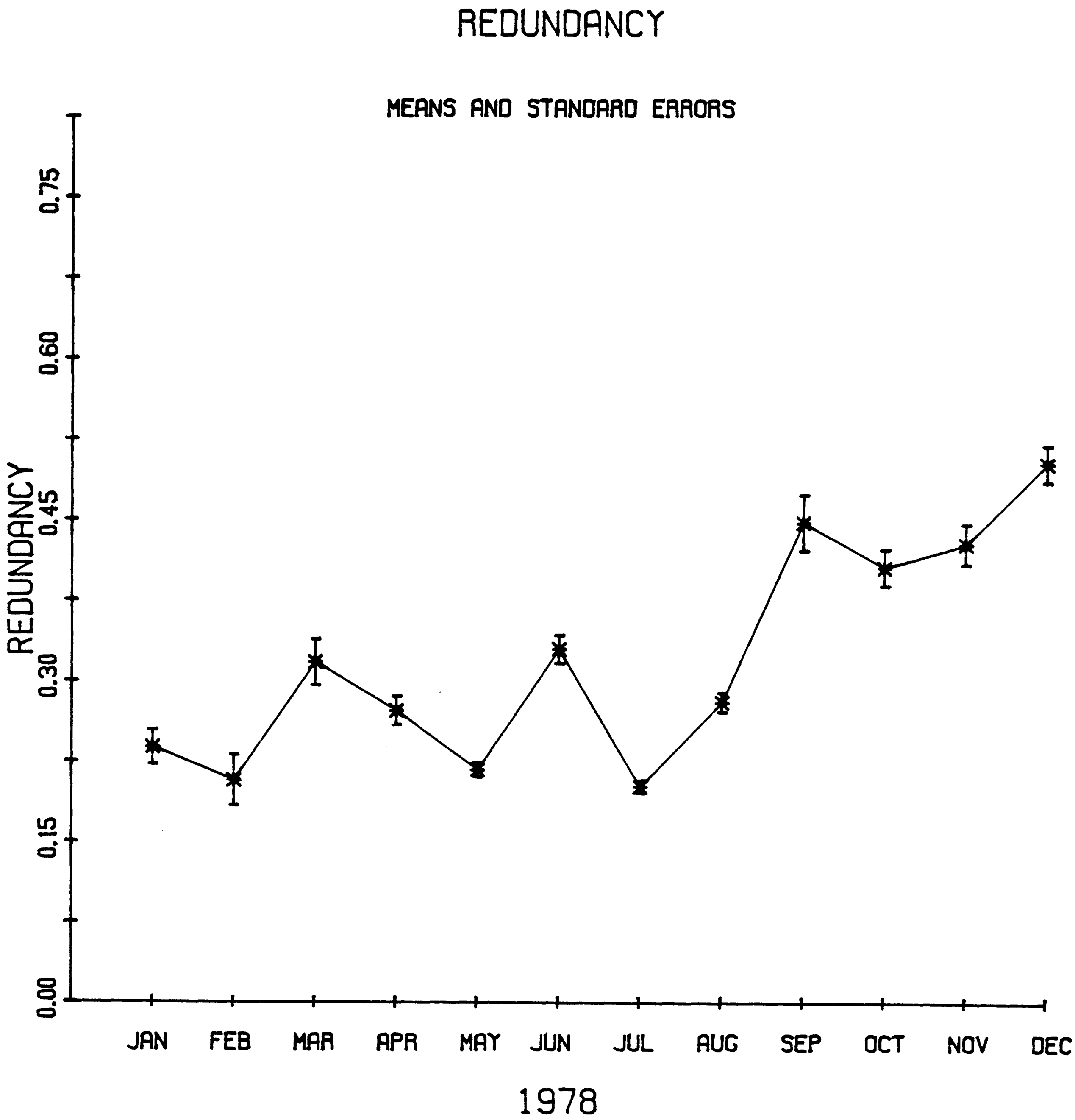

FIG. 14. Variation of redundancy during 1978.

by a few species, namely, <u>Fragilaria crotonensis</u>, <u>Anacystis incerta</u>, and <u>Gomphosphaeria lacustris</u>.

Numbers and Biomass of Phytoplankton Passing Through the Plant --

One of the major stress factors unique to entrained phytoplankton is the artificially elevated temperature in the condenser through which entrained phytoplankton must pass. The intake water temperature during 1977 varied from 1°C to over 23°C; after the water had passed through the cooling system, its temperature at the discharge was about 10 C° higher. In the summer, the discharge water temperature approached 34°C, the temperature suggested by Patrick (1969) as having a harmful effect on algae. Because of possible harmful effects on algae, the numbers and biomass of phytoplankton passing through the condenser and the possible effect of this impact on phytoplankton were assessed.

The plant pumped water at an average rate of 2,700 $m^3 \ min^{-1}$ for unit #1 and 3,500 $m^3 \ min^{-1}$ for unit #2. When both units were in operation, the average rate at which water was pumped through the plant was 6,200 $m^3 \ min^{-1}$. The mean monthly total phytoplankton densities were used to estimate the number of phytoplankton passing through the plant in each month. The weight of the phytoplankton was then computed using the conversion coefficient of 0.57×10^{-9}gm as the average weight of a phytoplankton cell (Ayers and Seibel 1973). Using these methods, an estimate of 7.85×10^{18} phytoplankton cells or 4.47×10^{9}gm of phytoplankton was obtained for total entrainment during January through December of 1978 (Table 31). Not all the annual estimates began in January and the units in operation were different in each year; therefore, it would not be appropriate to make annual comparisons of the total entrained

TABLE 31. Phytoplankton entrained by the plant during 1976, 1977, and 1978. (Mean and standard deviation are shown for 1977 and 1978 data, but only mean for 1976 data; --- indicates no data).

	Numbers Entrained		
Month	1976	1977	1978
January	4.25×10^{17}	---	1.79×10^{17} (0.25×10^{17})
February	1.59×10^{17}	---	5.06×10^{16} (0.89×10^{16})
March	2.22×10^{17}	2.87×10^{17} (0.81×10^{17})	8.21×10^{16} (0.44×10^{16})
April	3.49×10^{17}	4.32×10^{17} (1.30×10^{17})	2.27×10^{17} (0.26×10^{17})
May	5.45×10^{17}	2.13×10^{17} (0.85×10^{17})	7.58×10^{17} (0.62×10^{17})
June	1.81×10^{17}	1.83×10^{17} (0.96×10^{17})	1.09×10^{18} (0.70×10^{17})
July	9.57×10^{17}	2.53×10^{17} (0.60×10^{17})	1.08×10^{18} (0.90×10^{17})
August	3.79×10^{17}	2.48×10^{17} (1.17×10^{17})	4.05×10^{17} (0.48×10^{17})
September	5.89×10^{17}	1.88×10^{17} (0.53×10^{17})	3.63×10^{17} (0.30×10^{17})
October	3.28×10^{17}	3.07×10^{17} (1.15×10^{17})	1.26×10^{18} (1.24×10^{17})
November	3.60×10^{17}	3.56×10^{17} (1.64×10^{17})	9.91×10^{17} (1.13×10^{17})
December	3.46×10^{17}	2.11×10^{17} (0.76×10^{17})	1.36×10^{18} (1.10×10^{17})
Total	4.84×10^{18}	2.68×10^{18}	7.85×10^{18}

	Weight Entrained, (gms)		
Month	1976	1977	1978
January	2.42×10^{8}	---	1.02×10^{8} (0.14×10^{8})
February	9.06×10^{8}	---	2.89×10^{7} (0.51×10^{7})
March	1.27×10^{8}	1.64×10^{8} (0.46×10^{8})	4.68×10^{7} (0.25×10^{7})
April	1.99×10^{8}	2.46×10^{8} (0.74×10^{8})	1.30×10^{8} (0.14×10^{8})
May	3.11×10^{8}	1.21×10^{8} (0.48×10^{8})	4.34×10^{8} (0.35×10^{8})
June	1.04×10^{8}	1.03×10^{8} (0.55×10^{8})	6.24×10^{8} (0.40×10^{8})
July	5.45×10^{8}	1.44×10^{8} (0.34×10^{8})	6.14×10^{8} (0.51×10^{8})
August	2.16×10^{8}	1.41×10^{8} (0.76×10^{8})	2.30×10^{8} (0.28×10^{8})
September	3.36×10^{8}	1.07×10^{8} (0.30×10^{8})	2.07×10^{8} (0.17×10^{8})
October	1.87×10^{8}	1.75×10^{8} (0.66×10^{8})	7.15×10^{8} (0.71×10^{8})
November	2.05×10^{8}	2.03×10^{8} (0.93×10^{8})	5.66×10^{8} (0.64×10^{8})
December	1.97×10^{8}	1.20×10^{8} (0.43×10^{8})	7.73×10^{8} (0.62×10^{8})
Total	2.76×10^{9}	1.53×10^{9}	4.47×10^{9}

phytoplankton in numbers or weight. Furthermore, the above estimates were based on the assumption that the plant was operating 100% of the time and that no recirculation of discharge water occurred. Thus the monthly estimate represents a somewhat inflated value for the number and weight of phytoplankton passing through the plant during each month.

CHLOROPHYLLS AND PHAEOPHYTIN *a*

Chlorophylls *a*, *b*, and *c* and phaeophytin *a* data have been used 1) to monitor monthly changes in these variables with respect to observed phytoplankton densities, 2) to determine the percentage of change in these variables that would be detectable at the .05 level of significance, 3) to assess the appropriateness of the intake sampling location with all seven pumps running, 4) to assess immediate impact of entrainment on phytoplankton viability, and 5) to assess impact of entrainment on phytoplankton hours after entrainment. When phytoplankton pass through the plant, several possible alterations of the population's viability may occur. Among these are killing or damage to the organism during periods of chlorination, destruction or inhibition from heat, and stimulation of productivity due to increased temperatures or mechanical agitation.

Percentage of Change Detectable at the 0.05 Level of Significance

To establish the least change in each of the chlorophylls, phaeophytin *a*, and the phaeophytin *a* to chlorophyll *a* ratio that is detectable with 95% power by analysis of variance, the equation derived by Johnston (1974) from an equation of Sokal and Rohlf (1969, p. 247) was used. It is

$$\delta = \sigma \frac{2}{\eta} (t\alpha[\nu] + t_2 (1 - P) [\nu]) \text{ where}$$

δ = least detectable true difference

σ = true error standard deviation

ν = degrees of freedom of the error mean square

η = typical number of observations for each case

t = student's t

α = significance level

P = power (the desired probability that a difference will be found significant).

For $\alpha = 0.05$ and $P = 0.95$, δ may be calculated. The calculated 1978 δs for chlorophyll *a*, chlorophyll *b*, chlorophyll *c*, phaeophytin *a*, and the phaeophytin *a* to chlorophyll *a* ratio based on 99 cases consisting of five observations each are presented in Table 32. Compared to 1975 and 1976, the 1978 δ for each variable was less, and compared to 1977, the 1978 δ for each variable was similar (Rossmann *et al.* 1977, Rossmann *et al.* 1979, Rossmann *et al.* 1980). The downward trend in least detectable true difference may be attributed to the development and implementation in 1977 of a more quantitative chlorophyll extraction method (Rossmann *et al.* 1979, Rossmann *et al.* 1980).

Horizontal and Vertical Viability Heterogeneity

During September 1978, a set of samples was collected with both units operational and all seven circulating water pumps running. Tables 33 through 37 list results of the horizontal study. Significant variations at the 0.05 level occurred at 5.5 m for chlorophyll *a*, at 0.6 m for phaeophytin *a*, and at

TABLE 32. Least detectable true difference for the 1978 chlorophyll a, chlorophyll b, chlorophyll c, phaeophytin a, and the phaeophytin a to chlorophyll a ratio.[1]

Variable	Mean	True Error Standard Deviation	δ
Chlorophyll a	6.56	0.737	1.70
Chlorophyll b	0.0741	0.126	0.290
Chlorophyll c	1.08	0.332	0.764
Phaeophytin a	1.13	0.764	1.76
Phaeophytin a/ Chlorophyll a	0.243	0.264	0.608

[1] 0.95 probability that the differences will be significantly different at the 0.05 level.

0.6 m for the phaeophytin a/chlorophyll a ratio. This variability resulted from a relatively low chlorophyll a concentration at I2-5, a relatively high phaeophytin a concentration at I2-1, and a relatively high phaeophytin a to chlorophyll a ratio at I2-1 (Figure 1).

Tables 38 through 42 contain results of the vertical heterogeneity study. Sampling depths were 0.6 m, 5.5 m, and 8.5 m. Significant vertical differences at the 0.05 level of significance were found for chlorophyll a at I1-5 and I2-5, for chlorophyll b at I2-5, and for chlorophyll c at I2-5. The variation of chlorophyll a at I1-5 was due to an increase in chlorophyll a concentrations with increased depth. This is similar to results for one unit operating (Rossmann *et al*. 1977). The relatively low chlorophyll a, chlorophyll b, and chlorophyll c concentrations for the 5.5 m depth at I2-5 make this a poor choice for monthly entrainment sampling. Chlorophyll concentrations at I1-5

TABLE 33. Mean chlorophyll a concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	I1-2	0.6 5	0.410E+01	0.850E-01			
09/14/78	1430	I1-5	0.6 5	0.401E+01	0.547E-01			
09/14/78	1430	I2-1	0.6 4	0.386E+01	0.874E-01			
09/14/78	1430	I2-5	0.6 5	0.405E+01	0.111E+00	0.6 M HOR. VARIATION	0.129E+01	0.314E+00
09/14/78	1505	I1-2	5.5 5	0.488E+01	0.205E+00			
09/14/78	1505	I1-5	5.5 4	0.470E+01	0.121E+00			
09/14/78	1505	I2-1	5.5 3	0.434E+01	0.259E+00			
09/14/78	1505	I2-5	5.5 5	0.371E+01	0.242E+00	5.5 M HOR. VARIATION	0.658E+01	0.693E-02
09/14/78	1550	I1-2	8.5 4	0.450E+01	0.316E+00			
09/14/78	1550	I1-5	8.5 4	0.493E+01	0.161E+00			
09/14/78	1550	I2-1	8.5 4	0.419E+01	0.212E+00			
09/14/78	1550	I2-5	8.5 5	0.442E+01	0.627E-01	8.5 M HOR. VARIATION	0.232E+01	0.125E+00

TABLE 34. Mean chlorophyll b concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	I1-2 0.6	5	0.107E+00	0.386E-01			
09/14/78	1430	I1-5 0.6	5	0.106E+00	0.253E-01			
09/14/78	1430	I2-1 0.6	4	0.118E+00	0.569E-01			
09/14/78	1430	I2-5 0.6	5	0.770E-01	0.196E-01	0.6 M HOR. VARIATION	0.244E+00	0.861E+00
09/14/78	1505	I1-2 5.5	5	0.374E-01	0.171E-01			
09/14/78	1505	I1-5 5.5	4	0.919E-01	0.371E-01			
09/14/78	1505	I2-1 5.5	3	0.268E-01	0.268E-01			
09/14/78	1505	I2-5 5.5	5	0.347E-01	0.205E-01	5.5 M HOR. VARIATION	0.129E+01	0.319E+00
09/14/78	1550	I1-2 8.5	4	0.158E+00	0.550E-01			
09/14/78	1550	I1-5 8.5	4	0.191E+00	0.722E-01			
09/14/78	1550	I2-1 8.5	4	0.207E+00	0.363E-01			
09/14/78	1550	I2-5 8.5	5	0.166E+00	0.241E-01	8.5 M HOR. VARIATION	0.217E+00	0.879E+00

TABLE 35. Mean chlorophyll c concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	I1-2	0.6	5	0.527E+00	0.419E-01			
09/14/78	1430	I1-5	0.6	5	0.532E+00	0.268E-01			
09/14/78	1430	I2-1	0.6	4	0.441E+00	0.441E-01			
09/14/78	1430	I2-5	0.6	5	0.483E+00	0.223E-01	0.6 M HOR. VARIATION	0.145E+01	0.269E+00
09/14/78	1505	I1-2	5.5	5	0.484E+00	0.676E-01			
09/14/78	1505	I1-5	5.5	4	0.511E+00	0.786E-01			
09/14/78	1505	I2-1	5.5	3	0.456E+00	0.134E+00			
09/14/78	1505	I2-5	5.5	5	0.380E+00	0.432E-01	5.5 M HOR. VARIATION	0.629E+00	0.610E+00
09/14/78	1550	I1-2	8.5	4	0.405E+00	0.510E-01			
09/14/78	1550	I1-5	8.5	4	0.484E+00	0.109E+00			
09/14/78	1550	I2-1	8.5	4	0.661E+00	0.428E-01			
09/14/78	1550	I2-5	8.5	5	0.582E+00	0.429E-01	8.5 M HOR. VARIATION	0.286E+01	0.794E-01

TABLE 36. Mean phaeophytin *a* concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATF	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWFEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	I1-2	0.6 5	0.347E+00	0.950E-01			
09/14/78	1430	I1-5	0.6 5	0.358E+00	0.408E-01			
09/14/78	1430	I2-1	0.6 4	0.646E+00	0.776E-01			
09/14/78	1430	I2-5	0.6 5	0.236E+00	0.107E+00	0.6 M HOR. VARIATION	0.385E+01	0.329E-01
09/14/78	1505	I1-2	5.5 5	0.236E+00	0.680E-01			
09/14/78	1505	I1-5	5.5 4	0.300E+00	0.157E+00			
09/14/78	1505	I2-1	5.5 3	0.429E+00	0.266E+00			
09/14/78	1505	I2-5	5.5 5	0.346E+00	0.114E+00	5.5 M HOR. VARIATION	0.306E+00	0.818E+00
09/14/78	1550	I1-2	8.5 4	0.163E+00	0.769E-01			
09/14/78	1550	I1-5	8.5 4	0.815E-01	0.815E-01			
09/14/78	1550	I2-1	8.5 4	0.340E+00	0.152E+00			
09/14/78	1550	I2-5	8.5 5	0.363E+00	0.465E-01	8.5 M HETEROGENETIY	0.220E+01	0.138E+00

TABLE 37. Mean phaeophytin *a* to chlorophyll *a* ratios with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	I1-2 0.6	5	0.862E-01	0.241E-01			
09/14/78	1430	I1-5 0.6	5	0.896E-01	0.111E-01			
09/14/78	1430	I2-1 0.6	4	0.169E+00	0.224E-01			
09/14/78	1430	I2-5 0.6	5	0.607E-01	0.273E-01	0.6 M HOR. VARIATION	0.400E+01	0.293E-01
09/14/78	1505	I1-2 5.5	5	0.492E-01	0.140E-01			
09/14/78	1505	I1-5 5.5	4	0.661E-01	0.348E-01			
09/14/78	1505	I2-1 5.5	3	0.107E+00	0.704E-01			
09/14/78	1505	I2-5 5.5	5	0.958E-01	0.332E-01	5.5 M HOR. VARIATION	0.543E+00	0.662E+00
09/14/78	1550	I1-2 8.5	4	0.369E-01	0.164E-01			
09/14/78	1550	I1-5 8.5	4	0.175E-01	0.175E-01			
09/14/78	1550	I2-1 8.5	4	0.813E-01	0.343E-01			
09/14/78	1550	I2-5 8.5	5	0.823E-01	0.111E-01	8.5 M HOR. VARIATION	0.248E+01	0.109E+00

TABLE 38. Mean chlorophyll a concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	D1	5	0.353E+01	0.966E-01			
09/14/78	1505	D1	4	0.447E+01	0.123E+00			
09/14/78	1550	D1	5	0.445E+01	0.167E+00	D1 VARIATION	0.166E+02	0.861E-03
09/14/78	1430	D2	5	0.357E+01	0.781E-01			
09/14/78	1505	D2	4	0.413E+01	0.156E+00			
09/14/78	1550	D2	4	0.366E+01	0.187E+00	D2 VARIATION	0.456E+01	0.404E-01
09/14/78	1430	I1-2 0.6	5	0.410E+01	0.850E-01			
09/14/78	1505	I1-2 5.5	5	0.488E+01	0.205E+00			
09/14/78	1550	I1-2 8.5	4	0.450E+01	0.316E+00	I1-2 VERT. VARIATION	0.384E+01	0.555E-01
09/14/78	1430	I1-5 0.6	5	0.401E+01	0.547E-01			
09/14/78	1505	I1-5 5.5	4	0.470E+01	0.121E+00			
09/14/78	1550	I1-5 8.5	4	0.493E+01	0.161E+00	I1-5 VERT. VARIATION	0.190E+02	0.752E-03
09/14/78	1430	I2-1 0.6	4	0.386E+01	0.874E-01			
09/14/78	1505	I2-1 5.5	3	0.434E+01	0.259E+00			
09/14/78	1550	I2-1 8.5	4	0.419E+01	0.212E+00	I2-1 VERT. VARIATION	0.172E+01	0.240E+00
09/14/78	1430	I2-5 0.6	5	0.405E+01	0.111E+00			
09/14/78	1505	I2-5 5.5	5	0.371E+01	0.242E+00			
09/14/78	1550	I2-5 8.5	5	0.442E+01	0.627E-01	I2-5 VERT. VARIATION	0.513E+01	0.255E-01

TABLE 39. Mean chlorophyll b concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	D1	5	0.114E+00	0.196E-01			
09/14/78	1505	D1	4	0.161E+00	0.232E-01			
09/14/78	1550	D1	5	0.248E+00	0.414E-01	D1 VARIATION	0.521E+01	0.266E-01
09/14/78	1430	D2	5	0.210E+00	0.758E-01			
09/14/78	1505	D2	4	0.861E-01	0.164E-01			
09/14/78	1550	D2	4	0.188E+00	0.910E-02	D2 VARIATION	0.156E+01	0.259E+00
09/14/78	1430	I1-2 0.6	5	0.107E+00	0.386E-01			
09/14/78	1505	I1-2 5.5	5	0.374E-01	0.171E-01			
09/14/78	1550	I1-2 8.5	4	0.158E+00	0.550E-01	I1-2 VERT. VARIATION	0.255E+01	0.124E+00
09/14/78	1430	I1-5 0.6	5	0.106E+00	0.253E-01			
09/14/78	1505	I1-5 5.5	4	0.919E-01	0.371E-01			
09/14/78	1550	I1-5 8.5	4	0.191E+00	0.722E-01	I1-5 VERT. VARIATION	0.127E+01	0.325E+00
09/14/78	1430	I2-1 0.6	4	0.118E+00	0.569E-01			
09/14/78	1505	I2-1 5.5	3	0.268E-01	0.268E-01			
09/14/78	1550	I2-1 8.5	4	0.207E+00	0.363E-01	I2-1 VERT. VARIATION	0.382E+01	0.700E-01
09/14/78	1430	I2-5 0.6	5	0.770E-01	0.196E-01			
09/14/78	1505	I2-5 5.5	5	0.347E-01	0.205E-01			
09/14/78	1550	I2-5 8.5	5	0.166E+00	0.241E-01	I2-5 VERT. VARIATION	0.967E+01	0.387E-02

TABLE 40. Mean chlorophyll c concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	D1		5	0.361E+00	0.335E-01			
09/14/78	1505	D1		4	0.492E+00	0.514E-01			
09/14/78	1550	D1		5	0.544E+00	0.949E-01	D1 VARIATION	0.206E+01	0.174E+00
09/14/78	1430	D2		5	0.363E+00	0.482E-01			
09/14/78	1505	D2		4	0.424E+00	0.301E-01			
09/14/78	1550	D2		4	0.580E+00	0.483E-01	D2 VARIATION	0.638E+01	0.174E-01
09/14/78	1430	I1-2	0.6	5	0.527E+00	0.419E-01			
09/14/78	1505	I1-2	5.5	5	0.484E+00	0.676E-01			
09/14/78	1550	I1-2	8.5	4	0.405E+00	0.510E-01	I1-2 VERT. VARIATION	0.117E+01	0.348E+00
09/14/78	1430	I1-5	0.6	5	0.532E+00	0.268E-01			
09/14/78	1505	I1-5	5.5	4	0.511E+00	0.786E-01			
09/14/78	1550	I1-5	8.5	4	0.484E+00	0.109E+00	I1-5 VERT. VARIATION	0.111E+00	0.891E+00
09/14/78	1430	I2-1	0.6	4	0.441E+00	0.441E-01			
09/14/78	1505	I2-1	5.5	3	0.456E+00	0.134E+00			
09/14/78	1550	I2-1	8.5	4	0.661E+00	0.428E-01	I2-1 VERT. VARIATION	0.306E+01	0.105E+00
09/14/78	1430	I2-5	0.6	5	0.483E+00	0.223E-01			
09/14/78	1505	I2-5	5.5	5	0.380E+00	0.432E-01			
09/14/78	1550	I2-5	8.5	5	0.582E+00	0.429E-01	I2-5 VERT. VARIATION	0.727E+01	0.943E-02

TABLE 41. Mean phaeophytin a concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	D1		5	0.360E+00	0.147E+00			
09/14/78	1505	D1		4	0.362E+00	0.153E+00			
09/14/78	1550	D1		5	0.277E+00	0.122E+00	D1 VARIATION	0.124E+00	0.879E+00
09/14/78	1430	D2		5	0.314E+00	0.117E+00			
09/14/78	1505	D2		4	0.259E+00	0.127E+00			
09/14/78	1550	D2		4	0.379E+00	0.210E-01	D2 VARIATION	0.306E+00	0.742E+00
09/14/78	1430	I1-2	0.6	5	0.347E+00	0.950E-01			
09/14/78	1505	I1-2	5.5	5	0.236E+00	0.680E-01			
09/14/78	1550	I1-2	8.5	4	0.163E+00	0.769E-01	I1-2 VERT. VARIATION	0.125E+01	0.325E+00
09/14/78	1430	I1-5	0.6	5	0.358E+00	0.408E-01			
09/14/78	1505	I1-5	5.5	4	0.300E+00	0.157E+00			
09/14/78	1550	I1-5	8.5	4	0.815E-01	0.815E-01	I1-5 VERT. VARIATION	0.222E+01	0.160E+00
09/14/78	1430	I2-1	0.6	4	0.646E+00	0.776E-01			
09/14/78	1505	I2-1	5.5	3	0.429E+00	0.266E+00			
09/14/78	1550	I2-1	8.5	4	0.340E+00	0.152E+00	I2-1 VERT. VARIATION	0.101E+01	0.407E+00
09/14/78	1430	I2-5	0.6	5	0.236E+00	0.107E+00			
09/14/78	1505	I2-5	5.5	5	0.346E+00	0.114E+00			
09/14/78	1550	I2-5	8.5	5	0.363E+00	0.465E-01	I2-5 VERT. VARIATION	0.537E+00	0.600E+00

TABLE 42. Mean phaeophytin a to chlorophyll a ratio with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and depth of collection in meters.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/14/78	1430	D1	5	0.107E+00	0.466E-01			
09/14/78	1505	D1	4	0.838E-01	0.374E-01			
09/14/78	1550	D1	5	0.649E-01	0.299E-01	D1 VARIATION	0.306E+00	0.742E+00
09/14/78	1430	D2	5	0.903E-01	0.342E-01			
09/14/78	1505	D2	4	0.666E-01	0.339E-01			
09/14/78	1550	D2	4	0.104E+00	0.429E-02	D2 VARIATION	0.379E+00	0.695E+00
09/14/78	1430	I1-2 0.6	5	0.862E-01	0.241E-01			
09/14/78	1505	I1-2 5.5	5	0.492E-01	0.140E-01			
09/14/78	1550	I1-2 8.5	4	0.369E-01	0.164E-01	I1-2 VERT. VARIATION	0.181E+01	0.211E+00
09/14/78	1430	I1-5 0.6	5	0.896E-01	0.111E-01			
09/14/78	1505	I1-5 5.5	4	0.661E-01	0.348E-01			
09/14/78	1550	I1-5 8.5	4	0.175E-01	0.175E-01	I1-5 VERT. VARIATION	0.283E+01	0.108E+00
09/14/78	1430	I2-1 0.6	4	0.169E+00	0.224E-01			
09/14/78	1505	I2-1 5.5	3	0.107E+00	0.704E-01			
09/14/78	1550	I2-1 8.5	4	0.813E-01	0.343E-01	I2-1 VERT. VARIATION	0.128E+01	0.330E+00
09/14/78	1430	I2-5 0.6	5	0.607E-01	0.273E-01			
09/14/78	1505	I2-5 5.5	5	0.958E-01	0.332E-01			
09/14/78	1550	I2-5 8.5	5	0.823E-01	0.111E-01	I2-5 VERT. VARIATION	0.476E+00	0.634E+00

behaved in a manner similar to that when one unit was operational and were representative of chlorophyll and phaeophytin _a_ concentrations across the intake forebay. Thus I1-5 (MTR1-5) will continue to be the location of monthly phytoplankton entrainment sampling.

Assessment of Damage to Phytoplankton

Because the phaeophytin _a_ to chlorophyll _a_ ratio is relatively insensitive to changes in viability, chlorophyll data will be presented in a manner similar to the reports on the 1975, 1976, and 1977 data (Rossmann _et al_. 1977, Rossmann _et al_. 1979, Rossmann _et al_. 1980). Chlorophyll _a_ is the most sensitive of all the variables for detecting any change in viability.

During 1978, the number of comparisons between the intake and discharge samples suggested that a change in phytoplankton viability was nearly the same as that noted for 1977 (Table 43). The occurrence of significant ($P < .05$) changes in chlorophyll, phaeophytin _a_, and the phaeophytin _a_ to chlorophyll _a_ ratio during 1978 and 1977 was considerably higher than those of 1975 and 1976, corresponding to our change in methodology whereby grinding was used instead of sonification and five replicates were collected rather than three. The higher rate does not coincide with two unit operation.

Between the intake and discharge during 1978, chlorophyll _a_ decreased 22% of the time in all samples and 23% of the time in incubated samples (Table 44). Chlorophyll _a_ increased 12% of the time in all samples and 5% of the time in incubated samples. For all samples, chlorophyll _b_ (Table 45) increased 10% of the time and decreased 6% of the time. For incubated samples, it increased 23% of the time and decreased 8% of the time. For all samples, chlorophyll _c_ (Table 46) decreased in 8% of the samples and increased in 8% of them.

TABLE 43. Changes in viability noted by comparison of chlorophyll data from the intake with those from the discharges.

Year	% of Comparisons Showing Increase	% of Comparisons Showing Decrease
1975	2	4
1976	4	5
1977	1	16
1978	9	9

Incubated samples showed increases 10% of the time and showed decreases 0% of the time. For all samples, phaeophytin a (Table 47) increased 6% of the time and decreased 4% of the time. For the 1978 incubated samples, phaeophytin a decreased 3% of the time and increased 8% of the time. In 1978, the phaeophytin a/chlorophyll a ratio (Table 48) increased 6% of the time and decreased 6% of the time. For the 1978 incubated samples, the ratio decreased 8% of the time and increased 8% of the time.

During 1977, significant decreases in viability occurred in 32 of 205 comparisons or roughly 16% of the comparisons. This is high compared with 1975, 1976, and 1978. Increases in viability occurred in only 1 of 205 comparisons or roughly 1% of all comparisons in 1977. This is low compared to 1975, 1976, and 1978. For the 4 years compared, there has been a general rise in the occurrence of decreased viability with a sharp peak occurring in 1977. This decrease did not continue into 1978. As in 1975 and 1976, the percentage of comparisons showing an increase equalled those showing a decrease.

With the exception of 1977, when the character of the entrained phytoplankton community was such that a probable negative impact was noted,

TABLE 44. Mean chlorophyll a concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and number of hours after collection it was incubated.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5 0	5	0.446E+01	0.271E+00			
01/10/78	0730	D1 0	5	0.487E+01	0.327E+00	INTAKE VS. DISCHARGE	0.925E+00	0.367E+00
01/10/78	0730	I5 27	5	0.468E+01	0.695E+00			
01/10/78	0730	D1 27	5	0.408E+01	0.380E+00	INTAKE VS. DISCHARGE	0.566E+00	0.478E+00
01/11/78	1400	I5 0	4	0.381E+01	0.669E-01			
01/11/78	1400	D1 0	4	0.717E+01	0.236E+00	INTAKE VS. DISCHARGE	0.188E+03	0.139E-03
01/11/78	1400	I5 4	2	0.379E+01	0.0			
01/11/78	1400	D1 4	4	0.360E+01	0.307E+00	INTAKE VS. DISCHARGE	0.161E+00	0.703E+00
01/11/78	2000	I5 0	5	0.311E+01	0.151E+00			
01/11/78	2000	D1 0	5	0.360E+01	0.209E+00	INTAKE VS. DISCHARGE	0.361E+01	0.938E-01
02/06/78	2001	I5 0	5	0.135E+01	0.135E+00			
02/06/78	1950	D1 0	4	0.136E+01	0.644E-01	INTAKE VS. DISCHARGE	0.715E-02	0.923E+00
02/06/78	2001	I5 33	5	0.132E+01	0.468E-01			
02/06/78	1950	D1 33	5	0.156E+01	0.187E-01	INTAKE VS. DISCHARGE	0.220E+02	0.221E-02
02/08/78	0650	I5 0	5	0.153E+01	0.149E+00			
02/08/78	0650	D1 0	4	0.123E+01	0.171E+00	INTAKE VS. DISCHARGE	0.174E+01	0.229E+00
02/07/78	1215	I5 0	5	0.103E+01	0.251E+00			
02/07/78	1215	D1 0	5	0.127E+01	0.750E-01	INTAKE VS. DISCHARGE	0.805E+00	0.399E+00
03/06/78	2017	I5 0	5	0.220E+01	0.203E+00			
03/06/78	2017	D1 0	5	0.216E+01	0.111E+00	INTAKE VS. DISCHARGE	0.361E-01	0.840E+00
03/06/78	2017	I5 37	5	0.249E+01	0.917E-01			
03/06/78	2017	D1 37	5	0.363E+01	0.623E+00	INTAKE VS. DISCHARGE	0.330E+01	0.107E+00
03/07/78	0550	I5 0	4	0.188E+01	0.123E+00			
03/07/78	0550	D1 0	5	0.192E+01	0.823E-01	INTAKE VS. DISCHARGE	0.762E-01	0.780E+00
03/07/78	1230	I5 0	5	0.190E+01	0.223E+00			
03/07/78	1230	D1 0	5	0.197E+01	0.273E+00	INTAKE VS. DISCHARGE	0.330E-01	0.847E+00
04/10/78	2105	I5 0	5	0.287E+01	0.484E+00			
04/10/78	2105	D2 0	5	0.335E+01	0.178E+00	INTAKE VS. DISCHARGE	0.852E+00	0.386E+00
04/10/78	2105	I5 38	5	0.353E+01	0.218E+00			
04/10/78	2105	D2 38	5	0.342E+01	0.181E+00	INTAKE VS. DISCHARGE	0.167E+00	0.690E+00
04/11/78	0440	I5 0	5	0.172E+01	0.164E+00			
04/11/78	0440	D2 0	5	0.241E+01	0.490E+00	INTAKE VS. DISCHARGE	0.180E+01	0.216E+00

(continued)

TABLE 44. (continued).

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5 0	5	0.308E+01	0.302E+00			
04/11/78	1225	D2 0	5	0.317E+01	0.319E+00	INTAKE VS. DISCHARGE	0.498E-01	0.816E+00
05/09/78	2215	I5 0	5	0.114E+02	0.404E+00			
05/09/78	2215	D2 0	5	0.121E+02	0.224E+00	INTAKE VS. DISCHARGE	0.229E+01	0.168E+00
05/09/78	2215	I5 39	5	0.128E+02	0.399E+00			
05/09/78	2215	D2 39	5	0.128E+02	0.526E+00	INTAKE VS. DISCHARGE	0.367E-02	0.942E+00
05/10/78	0350	I5 0	5	0.136E+02	0.311E+00			
05/10/78	0340	D2 0	5	0.137E+02	0.219E+00	INTAKE VS. DISCHARGE	0.136E+00	0.717E+00
05/10/78	1219	I5 0	5	0.118E+02	0.177E+00			
05/10/78	1205	D2 0	4	0.107E+02	0.380E+00	INTAKE VS. DISCHARGE	0.700E+01	0.338E-01
06/12/78	2307	I5 0	5	0.120E+02	0.707E-01			
06/12/78	2310	D1 0	5	0.121E+02	0.198E+00	INTAKE VS. DISCHARGE	0.144E+00	0.709E+00
06/13/78	0010	I5 34	5	0.109E+02	0.265E+00			
06/13/78	2307	D1 34	5	0.119E+02	0.222E+00	INTAKE VS. DISCHARGE	0.835E+01	0.209E-01
06/13/78	0218	I5 0	5	0.154E+02	0.348E+00			
06/13/78	0220	D1 0	4	0.136E+02	0.771E+00	INTAKE VS. DISCHARGE	0.530E+01	0.552E-01
06/13/78	1237	I5 0	5	0.125E+02	0.200E+00			
06/13/78	1237	D1 0	5	0.117E+02	0.350E+00	INTAKE VS. DISCHARGE	0.355E+01	0.960E-01
07/11/78	2307	I5 0	5	0.161E+02	0.916E+00			
07/11/78	2315	D1 0	5	0.147E+02	0.589E+00			
07/11/78	2321	D2 0	5	0.166E+02	0.102E+01	INTAKE VS. DISCHARGE	0.129E+01	0.312E+00
07/11/78	2307	I5 34	5	0.192E+02	0.198E+00			
07/11/12	2315	D1 34	5	0.162E+02	0.641E+00			
07/11/78	2321	D2 34	5	0.193E+02	0.333E+00	INTAKE VS. DISCHARGE	0.172E+02	0.601E-03
07/11/78	0240	I5 0	5	0.155E+02	0.408E+00			
07/11/78	0240	D1 0	5	0.151E+02	0.818E+00			
07/11/78	0246	D2 0	5	0.147E+02	0.216E+00	INTAKE VS. DISCHARGE	0.574E+00	0.580E+00
07/11/78	1212	I5 0	5	0.111E+02	0.267E+00			
07/11/78	1213	D1 0	5	0.100E+02	0.179E+00			
07/11/78	1225	D2 0	5	0.109E+02	0.158E+00	INTAKE VS. DISCHARGE	0.757E+01	0.832E-02
08/07/78	2243	I5 0	5	0.400E+01	0.857E-01			
08/07/78	2238	D1 0	5	0.386E+01	0.109E+00			
08/07/78	2219	D2 0	5	0.451E+01	0.357E-01	INTAKE VS. DISCHARGE	0.167E+02	0.654E-03

(continued)

TABLE 44. (continued).

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5 35	5	0.389E+01	0.103E+00			
08/07/78	2238	D1 35	3	0.368E+01	0.533E-01			
08/08/78	2219	D2 35	5	0.387E+01	0.835E-01	INTAKE VS. DISCHARGE	0.123E+01	0.335E+00
08/08/78	0340	I5 0	5	0.388E+01	0.939E-01			
08/08/78	0335	D1 0	5	0.462E+01	0.694E-01			
08/08/78	0335	D2 0	5	0.360E+01	0.129E+00	INTAKE VS. DISCHARGE	0.274E+02	0.140E-03
08/08/78	1233	I5 0	5	0.240E+01	0.773E-01			
08/08/78	1225	D1 0	5	0.185E+01	0.460E-01			
08/08/78	1229	D2 0	5	0.216E+01	0.122E-01	INTAKE VS. DISCHARGE	0.283E+02	0.127E-03
09/11/78	2115	I5 0	5	0.195E+01	0.136E+00			
09/11/78	2115	D1 0	5	0.161E+01	0.999E-01			
09/11/78	2115	D2 0	5	0.146E+01	0.113E+00	INTAKE VS. DISCHARGE	0.442E+01	0.374E-01
09/11/78	2115	I5 37	5	0.108E+01	0.269E-01			
09/11/78	2115	D1 37	5	0.128E+01	0.666E-01			
09/11/78	2115	D2 37	5	0.119E+01	0.880E-01	INTAKE VS. DISCHARGE	0.242E+01	0.132E+00
09/12/78	0555	I5 0	5	0.214E+01	0.107E+00			
09/12/78	0555	D1 0	5	0.174E+01	0.430E-01			
09/12/78	0554	D2 0	5	0.211E+01	0.904E-01	INTAKE VS. DISCHARGE	0.672E+01	0.119E-01
09/12/78	1207	I5 0	5	0.312E+01	0.639E-01			
09/12/78	1200	D1 0	5	0.297E+01	0.499E-01			
09/12/78	1215	D2 0	5	0.349E+01	0.559E-01	INTAKE VS. DISCHARGE	0.223E+02	0.261E-03
10/09/78	2007	I5 0	5	0.935E+01	0.507E+00			
10/09/78	2000	D1 0	5	0.947E+01	0.364E+00			
10/09/78	2004	D2 0	4	0.956E+01	0.202E+00	INTAKE VS DISCHARGE	0.681E-01	0.930E+00
10/09/78	2007	I5 36	5	0.101E+02	0.247E+00			
10/09/78	2000	D1 36	5	0.853E+01	0.377E+00			
10/09/78	2004	D2 36	5	0.796E+01	0.217E+00	INTAKE VS DISCHARGE	0.145E+02	0.104E-02
10/10/78	0533	I5 0	5	0.794E+01	0.135E+00			
10/10/78	0520	D1 0	4	0.802E+01	0.148E+00			
10/10/78	0523	D2 0	4	0.809E+01	0.785E-01	INTAKE VS DISCHARGE	0.383E+00	0.692E+00
10/10/78	1218	I5 0	5	0.757E+01	0.145E+00			
10/10/78	1200	D1 0	5	0.702E+01	0.213E+00			
10/10/78	1213	D2 0	5	0.672E+01	0.108E+00	INTAKE VS DISCHARGE	0.724E+01	0.956E-02

(continued)

TABLE 44. (continued).

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5 0	3	0.534E+01	0.223E+00			
11/13/78	1910	D1 0	5	0.472E+01	0.139E+00	INTAKE VS DISCHARGE	0.621E+01	0.479E-01
11/13/78	1925	I5 36	5	0.551E+01	0.244E+00			
11/13/78	1910	D1 36	5	0.478E+01	0.186E+00	INTAKE VS DISCHARGE	0.572E+01	0.441E-01
11/14/78	0615	I5 0	5	0.579E+01	0.142E+00			
11/14/78	0557	D1 0	4	0.571E+01	0.396E+00	INTAKE VS DISCHARGE	0.344E-01	0.844E+00
11/14/78	1215	I5 0	4	0.710E+01	0.235E+00			
11/14/78	1200	D1 0	5	0.670E+01	0.192E+00	INTAKE VS DISCHARGE	0.181E+01	0.220E+00
12/04/78	1910	I5 0	5	0.623E+01	0.712E+00			
12/04/78	1931	D1 0	5	0.578E+01	0.774E+00			
12/04/78	1900	D2 0	5	0.708E+01	0.178E+00	INTAKE VS DISCHARGE	0.115E+01	0.350E+00
12/04/78	1910	I5 34	5	0.713E+01	0.364E+00			
12/04/78	1931	D1 34	5	0.624E+01	0.501E+00			
12/04/78	1900	D2 34	5	0.588E+01	0.242E+00	INTAKE VS DISCHARGE	0.282E+01	0.101E+00
12/05/78	0620	I5 0	5	0.684E+01	0.102E+00			
12/05/78	0635	D1 0	5	0.642E+01	0.242E+00			
12/05/78	0610	D2 0	5	0.584E+01	0.777E+00	INTAKE VS DISCHARGE	0.113E+01	0.358E+00
12/05/78	1206	I5 0	4	0.614E+01	0.382E+00			
12/05/78	1215	D1 0	4	0.699E+01	0.261E+00			
12/05/78	1150	D2 0	3	0.716E+01	0.113E+00	INTAKE VS DISCHARGE	0.334E+01	0.898E-01

TABLE 45. Mean chlorophyll b concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and number of hours after collection it was incubated.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5	0	5	0.493E-01	0.372E-01			
01/10/78	0730	D1	0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.175E+01	0.223E+00
01/10/78	0730	I5	27	5	0.200E-03	0.200E-03			
01/10/78	0730	D1	27	5	0.670E-02	0.645E-02	INTAKE VS. DISCHARGE	0.101E+01	0.345E+00
01/11/78	1400	I5	0	4	0.0	0.0			
01/11/78	1400	D1	0	4	0.130E-02	0.129E-02	INTAKE VS. DISCHARGE	0.100E+01	0.358E+00
01/11/78	1400	I5	4	2	0.0	0.0			
01/11/78	1400	D1	4	4	0.551E-01	0.205E-01	INTAKE VS. DISCHARGE	0.320E+01	0.150E+00
01/11/78	2000	I5	0	5	0.436E+00	0.411E+00			
01/11/78	2000	D1	0	5	0.300E-01	0.132E-01	INTAKE VS. DISCHARGE	0.973E+00	0.355E+00
02/06/78	2001	I5	0	5	C.150E+00	0.323E-01			
02/06/78	1950	D1	0	4	0.129E+00	0.171E-01	INTAKE VS. DISCHARGE	0.279E+00	0.615E+00
02/06/78	2001	I5	33	5	0.393E-01	0.131E-01			
02/06/78	1950	D1	33	5	0.139E+00	0.179E-01	INTAKE VS. DISCHARGE	0.202E+02	0.269E-02
02/08/78	0650	I5	0	5	0.835E-01	0.318E-01			
02/08/78	0650	D1	0	4	0.795E-01	0.122E-01	INTAKE VS. DISCHARGE	0.113E-01	0.905E+00
02/07/78	1215	I5	0	5	0.408E-01	0.685E-02			
02/07/78	1215	D1	0	5	0.444E-02	0.274E-02	INTAKE VS. DISCHARGE	0.243E+02	0.172E-02
03/06/78	2017	I5	0	5	0.926E-01	0.326E-01			
03/06/78	2017	D1	0	5	0.799E-01	0.148E-01	INTAKE VS. DISCHARGE	0.125E+00	0.726E+00
03/06/78	2017	I5	37	5	0.347E+00	0.173E+00			
03/06/78	2017	D1	37	5	0.518E-01	0.212E-01	INTAKE VS. DISCHARGE	0.288E+01	0.128E+00
03/07/78	0550	I5	0	4	0.808E-01	0.179E-01			
03/07/78	0550	D1	0	5	0.731E-01	0.242E-01	INTAKE VS. DISCHARGE	0.604E-01	0.801E+00
03/07/78	1230	I5	0	5	0.674E-01	0.190E-01			
03/07/78	1230	D1	0	5	0.162E-01	0.835E-02	INTAKE VS. DISCHARGE	0.608E+01	0.393E-01
04/10/78	2105	I5	0	5	C.128E-01	0.582E-02			
04/10/78	2105	D2	0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.469E+01	0.622E-01
04/10/78	2105	I5	38	5	0.945E-01	0.389E-01			
04/10/78	2105	D2	38	5	0.551E-01	0.239E-01	INTAKE VS. DISCHARGE	0.746E+00	0.416E+00
04/11/78	0440	I5	0	5	0.849E-02	0.784E-02			
04/11/78	0440	D2	0	5	0.177E-01	0.177E-01	INTAKE VS. DISCHARGE	0.228E+00	0.646E+00

(continued)

TABLE 45. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5	0	5	0.195E-01	0.136E-01			
04/11/78	1225	D2	0	5	0.447E-01	0.208E-01	INTAKE VS. DISCHARGE	0.102E+01	0.343E+00
05/09/78	2215	I5	0	5	0.938E-01	0.735E-01			
05/09/78	2215	D2	0	5	0.609E-01	0.495E-01	INTAKE VS. DISCHARGE	0.138E+00	0.714E+00
05/09/78	2215	I5	39	5	0.808E-01	0.512E-01			
05/09/78	2215	D2	39	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.248E+01	0.154E+00
05/10/78	0350	I5	0	5	0.184E-01	0.184E-01			
05/10/78	0340	D2	0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.978E+00	0.353E+00
05/10/78	1219	I5	0	5	0.308E-01	0.234E-01			
05/10/78	1205	D2	0	4	0.158E-01	0.158E-01	INTAKE VS. DISCHARGE	0.251E+00	0.632E+00
06/12/78	2307	I5	0	5	0.139E+00	0.128E+00			
06/12/78	2310	D1	0	5	0.0	0.0	INTAKE VS. DISCHARGE	0.118E+01	0.311E+00
06/13/78	0010	I5	34	5	0.866E-01	0.866E-01			
06/13/78	2307	D1	34	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.995E+00	0.349E+00
06/13/78	0218	I5	0	5	0.200E-03	0.200E-03			
06/13/78	0220	D1	0	4	0.250E-03	0.250E-03	INTAKE VS. DISCHARGE	0.251E-01	0.865E+00
06/13/78	1237	I5	0	5	0.784E-02	0.759E-02			
06/13/78	1237	D1	0	5	0.248E-02	0.248E-02	INTAKE VS. DISCHARGE	0.450E+00	0.525E+00
07/11/78	2307	I5	0	5	0.200E-03	0.200E-03			
07/11/78	2315	D1	0	5	0.200E-01	0.173E-01			
07/11/78	2321	D2	0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.131E+01	0.306E+00
07/11/78	2307	I5	34	5	0.699E-01	0.520E-01			
07/11/12	2315	D1	34	5	0.200E-03	0.200E-03			
07/11/78	2321	D2	34	5	0.238E-01	0.238E-01	INTAKE VS. DISCHARGE	0.115E+01	0.350E+00
07/11/78	0240	I5	0	5	0.246E-01	0.246E-01			
07/11/78	0240	D1	0	5	0.966E-01	0.966E-01			
07/11/78	0246	D2	0	5	0.674E-01	0.674E-01	INTAKE VS. DISCHARGE	0.272E+00	0.765E+00
07/11/78	1212	I5	0	5	0.398E-01	0.398E-01			
07/11/78	1213	D1	0	5	0.587E-01	0.418E-01			
07/11/78	1225	D2	0	5	0.416E-01	0.193E-01	INTAKE VS. DISCHARGE	0.882E-01	0.911E+00
08/07/78	2243	I5	0	5	0.150E+00	0.449E-01			
08/07/78	2238	D1	0	5	0.241E+00	0.191E-01			
08/07/78	2219	D2	0	5	0.183E+00	0.624E-01	INTAKE VS. DISCHARGE	0.101E+01	0.394E+00

(continued)

TABLE 45. (continued).

DATE	TIME		INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5	35	5	0.109E+00	0.558E-02			
08/07/78	2238	D1	35	3	0.153E+00	0.633E-02			
08/08/78	2219	D2	35	5	0.505E-01	0.239E-01	INTAKE VS. DISCHARGE	0.857E+01	0.772E-02
08/08/78	0340	I5	0	5	0.100E+00	0.257E-01			
08/08/78	0335	D1	0	5	0.148E+00	0.290E-01			
08/08/78	0335	D2	0	5	0.130E+00	0.251E-01	INTAKE VS. DISCHARGE	0.824E+00	0.465E+00
08/08/78	1233	I5	0	5	0.108E+00	0.133E-01			
08/08/78	1225	D1	0	5	0.835E-01	0.111E-01			
08/08/78	1229	D2	0	5	0.110E+00	0.180E-01	INTAKE VS. DISCHARGE	0.106E+01	0.380E+00
09/11/78	2115	I5	0	5	0.633E-01	0.161E-01			
09/11/78	2115	D1	0	5	0.732E-01	0.163E-01			
09/11/78	2115	D2	0	5	0.845E-01	0.149E-01	INTAKE VS. DISCHARGE	0.456E+00	0.647E+00
09/11/78	2115	I5	37	5	0.766E-01	0.120E-01			
09/11/78	2115	D1	37	5	0.137E+00	0.219E-01			
09/11/78	2115	D2	37	5	0.776E-01	0.125E-01	INTAKE VS. DISCHARGE	0.463E+01	0.334E-01
09/12/78	0555	I5	0	5	0.185E-01	0.103E-01			
09/12/78	0555	D1	0	5	0.673E-01	0.103E-01			
09/12/78	0554	D2	0	5	0.201E-01	0.897E-02	INTAKE VS. DISCHARGE	0.786E+01	0.742E-02
09/12/78	1207	I5	0	5	0.925E-01	0.159E-01			
09/12/78	1200	D1	0	5	0.879E-01	0.851E-02			
09/12/78	1215	D2	0	5	0.151E+00	0.155E-01	INTAKE VS. DISCHARGE	0.656E+01	0.128E-01
10/09/78	2007	I5	0	5	0.167E+00	0.869E-01			
10/09/78	2000	D1	0	5	0.170E+00	0.803E-01			
10/09/78	2004	D2	0	4	0.255E+00	0.746E-01	INTAKE VS DISCHARGE	0.339E+00	0.720E+00
10/09/78	2007	I5	36	5	0.772E-01	0.369E-01			
10/09/78	2000	D1	36	5	0.140E+00	0.429E-01			
10/09/78	2004	D2	36	5	0.944E-01	0.457E-01	INTAKE VS DISCHARGE	0.603E+00	0.565E+00
10/10/78	0533	I5	0	5	0.317E-01	0.151E-01			
10/10/78	0520	D1	0	4	0.179E+00	0.992E-01			
10/10/78	0523	D2	0	4	0.161E+00	0.483E-01	INTAKE VS DISCHARGE	0.197E+01	0.191E+00
10/10/78	1218	I5	0	5	0.106E+00	0.293E-01			
10/10/78	1200	D1	0	5	0.183E+00	0.520E-01			
10/10/78	1213	D2	0	5	0.762E-01	0.251E-01	INTAKE VS DISCHARGE	0.218E+01	0.157E+00

(continued)

TABLE 45. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5	0	3	0.549E-01	0.302E-01			
11/13/78	1910	D1	0	5	0.442E-01	0.255E-01	INTAKE VS DISCHARGE	0.704E-01	0.788E+00
11/13/78	1925	I5	36	5	0.125E-01	0.565E-02			
11/13/78	1910	D1	36	5	0.124E+00	0.572E-01	INTAKE VS DISCHARGE	0.378E+01	0.876E-01
11/14/78	0615	I5	0	5	0.790E-01	0.256E-01			
11/14/78	0557	D1	0	4	0.557E-01	0.191E-01	INTAKE VS DISCHARGE	0.480E+00	0.514E+00
11/14/78	1215	I5	0	4	0.148E+00	0.576E-01			
11/14/78	1200	D1	0	5	0.185E+00	0.330E-01	INTAKE VS DISCHARGE	0.338E+00	0.581E+00
12/04/78	1910	I5	0	5	0.167E+00	0.685E-01			
12/04/78	1931	D1	0	5	0.421E-01	0.238E-01			
12/04/78	1900	D2	0	5	0.122E+00	0.236E-01	INTAKE VS DISCHARGE	0.206E+01	0.171E+00
12/04/78	1910	I5	34	5	0.270E-02	0.270E-02			
12/04/78	1931	D1	34	5	0.455E-01	0.294E-01			
12/04/78	1900	D2	34	5	0.319E-01	0.147E-01	INTAKE VS DISCHARGE	0.131E+01	0.306E+00
12/05/78	0620	I5	0	5	0.669E-01	0.278E-01			
12/05/78	0635	D1	0	5	0.356E-01	0.161E-01			
12/05/78	0610	D2	0	5	0.445E-01	0.209E-01	INTAKE VS DISCHARGE	0.533E+00	0.602E+00
12/05/78	1206	I5	0	4	0.136E+00	0.518E-01			
12/05/78	1215	D1	0	4	0.122E+00	0.737E-01			
12/05/78	1150	D2	0	3	0.450E-01	0.238E-01	INTAKE VS DISCHARGE	0.623E+00	0.563E+00

TABLE 46. Mean chlorophyll c concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and number of hours after collection it was incubated.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5 0	5	0.115E+01	0.867E-01			
01/10/78	0730	D1 0	5	0.105E+01	0.796E-01	INTAKE VS. DISCHARGE	0.677E+00	0.438E+00
01/10/78	0730	I5 27	5	0.108E+01	0.133E+00			
01/10/78	0730	D1 27	5	0.861E+00	0.850E-01	INTAKE VS. DISCHARGE	0.189E+01	0.206E+00
01/11/78	1400	I5 0	4	0.765E+00	0.891E-01			
01/11/78	1400	D1 0	4	0.128E+01	0.988E-01	INTAKE VS. DISCHARGE	0.147E+02	0.974E-02
01/11/78	1400	I5 4	2	0.106E+01	0.600E-01			
01/11/78	1400	D1 4	4	0.108E+01	0.399E-01	INTAKE VS. DISCHARGE	0.536E-01	0.815E+00
01/11/78	2000	I5 0	5	0.669E+00	0.169E+00			
01/11/78	2000	D1 0	5	0.859E+00	0.483E-01	INTAKE VS. DISCHARGE	0.117E+01	0.311E+00
02/06/78	2001	I5 0	5	0.378E+00	0.681E-01			
02/06/78	1950	D1 0	4	0.526E+00	0.763E-01	INTAKE VS. DISCHARGE	0.216E+01	0.185E+00
02/06/78	2001	I5 33	5	0.371E+00	0.437E-01			
02/06/78	1950	D1 33	5	0.594E+00	0.858E-01	INTAKE VS. DISCHARGE	0.534E+01	0.499E-01
02/08/78	0650	I5 0	5	0.281E+00	0.748E-01			
02/08/78	0650	D1 0	4	0.268E+00	0.501E-01	INTAKE VS. DISCHARGE	0.175E-01	0.885E+00
02/07/78	1215	I5 0	5	0.349E+00	0.517E-01			
02/07/78	1215	D1 0	5	0.270E+00	0.322E-01	INTAKE VS. DISCHARGE	0.172E+01	0.226E+00
03/06/78	2017	I5 0	5	0.603E+00	0.920E-01			
03/06/78	2017	D1 0	5	0.664E+00	0.269E-01	INTAKE VS. DISCHARGE	0.405E+00	0.546E+00
03/06/78	2017	I5 37	5	0.140E+01	0.505E+00			
03/06/78	2017	D1 37	5	0.449E+00	0.886E-01	INTAKE VS. DISCHARGE	0.347E+01	0.994E-01
03/07/78	0550	I5 0	4	0.649E+00	0.302E-01			
03/07/78	0550	D1 0	5	0.498E+00	0.510E-01	INTAKE VS. DISCHARGE	0.568E+01	0.492E-01
03/07/78	1230	I5 0	5	0.526E+00	0.307E-01			
03/07/78	1230	D1 0	5	0.449E+00	0.341E-01	INTAKE VS. DISCHARGE	0.283E+01	0.131E+00
04/10/78	2105	I5 0	5	0.470E+00	0.316E-01			
04/10/78	2105	D2 0	5	0.639E+00	0.145E-01	INTAKE VS. DISCHARGE	0.237E+02	0.183E-02
04/10/78	2105	I5 38	5	0.478E+00	0.371E-01			
04/10/78	2105	D2 38	5	0.509E+00	0.493E-01	INTAKE VS. DISCHARGE	0.249E+00	0.632E+00
04/11/78	0440	I5 0	5	0.445E+00	0.500E-01			
04/11/78	0440	D2 0	5	0.427E+00	0.449E-01	INTAKE VS. DISCHARGE	0.686E-01	0.789E+00

(continued)

TABLE 46. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5	0	5	0.449E+00	0.517E-01			
04/11/78	1225	D2	0	5	0.481E+00	0.571E-01	INTAKE VS. DISCHARGE	0.177E+00	0.682E+00
05/09/78	2215	I5	0	5	0.141E+01	0.752E-01			
05/09/78	2215	D2	0	5	0.169E+01	0.717E-01	INTAKE VS. DISCHARGE	0.737E+01	0.270E-01
05/09/78	2215	I5	39	5	0.158E+01	0.128E+00			
05/09/78	2215	D2	39	5	0.185E+01	0.141E+00	INTAKE VS. DISCHARGE	0.207E+01	0.188E+00
05/10/78	0350	I5	0	5	0.192E+01	0.151E+00			
05/10/78	0340	D2	0	5	0.206E+01	0.143E+00	INTAKE VS. DISCHARGE	0.453E+00	0.524E+00
05/10/78	1219	I5	0	5	0.162E+01	0.100E+00			
05/10/78	1205	D2	0	4	0.141E+01	0.255E+00	INTAKE VS. DISCHARGE	0.701E+00	0.434E+00
06/12/78	2307	I5	0	5	0.287E+01	0.568E+00			
06/12/78	2310	D1	0	5	0.246E+01	0.832E-01	INTAKE VS. DISCHARGE	0.510E+00	0.499E+00
06/13/78	0010	I5	34	5	0.254E+01	0.421E+00			
06/13/78	2307	D1	34	5	0.248E+01	0.141E+00	INTAKE VS. DISCHARGE	0.171E-01	0.886E+00
06/13/78	0218	I5	0	5	0.267E+01	0.126E+00			
06/13/78	0220	D1	0	4	0.242E+01	0.972E-01	INTAKE VS. DISCHARGE	0.214E+01	0.187E+00
06/13/78	1237	I5	0	5	0.217E+01	0.899E-01			
06/13/78	1237	D1	0	5	0.175E+01	0.501E-01	INTAKE VS. DISCHARGE	0.172E+02	0.401E-02
07/11/78	2307	I5	0	5	0.282E+01	0.144E+00			
07/11/78	2315	D1	0	5	0.254E+01	0.143E+00			
07/11/78	2321	D2	0	5	0.284E+01	0.128E+00	INTAKE VS. DISCHARGE	0.151E+01	0.261E+00
07/11/78	2307	I5	34	5	0.284E+01	0.235E+00			
07/11/12	2315	D1	34	5	0.240E+01	0.236E+00			
07/11/78	2321	D2	34	5	0.265E+01	0.243E+00	INTAKE VS. DISCHARGE	0.849E+00	0.454E+00
07/11/78	0240	I5	0	5	0.238E+01	0.935E-01			
07/11/78	0240	D1	0	5	0.245E+01	0.687E-01			
07/11/78	0246	D2	0	5	0.215E+01	0.128E+00	INTAKE VS. DISCHARGE	0.250E+01	0.125E+00
07/11/78	1212	I5	0	5	0.183E+01	0.104E+00			
07/11/78	1213	D1	0	5	0.165E+01	0.182E+00			
07/11/78	1225	D2	0	5	0.192E+01	0.154E+00	INTAKE VS. DISCHARGE	0.855E+00	0.452E+00
08/07/78	2243	I5	0	5	0.691E+00	0.758E-01			
08/07/78	2238	D1	0	5	0.719E+00	0.616E-01			
08/07/78	2219	D2	0	5	0.745E+00	0.717E-01	INTAKE VS. DISCHARGE	0.150E+00	0.858E+00

(continued)

TABLE 46. (continued).

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5 35	5	0.446E+00	0.176E-01			
08/07/78	2238	D1 35	3	0.315E+00	0.158E+00			
08/08/78	2219	D2 35	5	0.519E+00	0.856E-01	INTAKE VS. DISCHARGE	0.129E+01	0.318E+00
08/08/78	0340	I5 0	5	0.571E+00	0.581E-01			
08/08/78	0335	D1 0	5	0.713E+00	0.147E-01			
08/08/78	0335	D2 0	5	0.556E+00	0.300E-01	INTAKE VS. DISCHARGE	0.501E+01	0.271E-01
08/08/78	1233	I5 0	5	0.484E+00	0.317E-01			
08/08/78	1225	D1 0	5	0.399E+00	0.397E-01			
08/08/78	1229	D2 0	5	0.384E+00	0.495E-01	INTAKE VS. DISCHARGE	0.175E+01	0.217E+00
09/11/78	2115	I5 0	5	0.500E+00	0.465E-01			
09/11/78	2115	D1 0	5	0.401E+00	0.460E-01			
09/11/78	2115	D2 0	5	0.451E+00	0.580E-01	INTAKE VS. DISCHARGE	0.962E+00	0.412E+00
09/11/78	2115	I5 37	5	0.326E+00	0.203E-01			
09/11/78	2115	D1 37	5	0.433E+00	0.621E-01			
09/11/78	2115	D2 37	5	0.330E+00	0.287E-01	INTAKE VS. DISCHARGE	0.216E+01	0.159E+00
09/12/78	0555	I5 0	5	0.395E+00	0.783E-01			
09/12/78	0555	D1 0	5	0.487E+00	0.502E-01			
09/12/78	0554	D2 0	5	0.509E+00	0.496E-01	INTAKE VS. DISCHARGE	0.993E+00	0.401E+00
09/12/78	1207	I5 0	5	0.654E+00	0.285E-01			
09/12/78	1200	D1 0	5	0.578E+00	0.416E-01			
09/12/78	1215	D2 0	5	0.448E+00	0.114E+00	INTAKE VS. DISCHARGE	0.208E+01	0.169E+00
10/09/78	2007	I5 0	5	0.628E+00	0.263E+00			
10/09/78	2000	D1 0	5	0.179E+01	0.712E+00			
10/09/78	2004	D2 0	4	0.141E+01	0.211E+00	INTAKE VS DISCHARGE	0.159E+01	0.249E+00
10/09/78	2007	I5 36	5	0.119E+01	0.138E+00			
10/09/78	2000	D1 36	5	0.100E+01	0.133E+00			
10/09/78	2004	D2 36	5	0.995E+00	0.793E-01	INTAKE VS DISCHARGE	0.886E+00	0.440E+00
10/10/78	0533	I5 0	5	0.107E+01	0.460E-01			
10/10/78	0520	D1 0	4	0.938E+00	0.966E-01			
10/10/78	0523	D2 0	4	0.961E+00	0.826E-01	INTAKE VS DISCHARGE	0.102E+01	0.396E+00
10/10/78	1218	I5 0	5	0.108E+01	0.739E-01			
10/10/78	1200	D1 0	5	0.844E+00	0.861E-01			
10/10/78	1213	D2 0	5	0.969E+00	0.102E+00	INTAKE VS DISCHARGE	0.183E+01	0.203E+00

(continued)

TABLE 46. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5	0	3	0.866E+00	0.809E-01			
11/13/78	1910	D1	0	5	0.649E+00	0.597E-01	INTAKE VS DISCHARGE	0.482E+01	0.712E-01
11/13/78	1925	I5	36	5	0.749E+00	0.101E+00			
11/13/78	1910	D1	36	5	0.480E+00	0.448E-01	INTAKE VS DISCHARGE	0.592E+01	0.414E-01
11/14/78	0615	I5	0	5	0.854E+00	0.680E-01			
11/14/78	0557	D1	0	4	0.786E+00	0.212E-01	INTAKE VS DISCHARGE	0.725E+00	0.426E+00
11/14/78	1215	I5	0	4	0.960E+00	0.119E+00			
11/14/78	1200	D1	0	5	0.109E+01	0.778E-01	INTAKE VS DISCHARGE	0.960E+00	0.362E+00
12/04/78	1910	I5	0	5	0.931E+00	0.111E+00			
12/04/78	1931	D1	0	5	0.101E+01	0.101E+00			
12/04/78	1900	D2	0	5	0.101E+01	0.506E-01	INTAKE VS DISCHARGE	0.260E+00	0.773E+00
12/04/78	1910	I5	34	5	0.912E+00	0.158E+00			
12/04/78	1931	D1	34	5	0.719E+00	0.851E-01			
12/04/78	1900	D2	34	5	0.572E+00	0.384E-01	INTAKE VS DISCHARGE	0.259E+01	0.117E+00
12/05/78	0620	I5	0	5	0.925E+00	0.473E-01			
12/05/78	0635	D1	0	5	0.894E+00	0.919E-01			
12/05/78	0610	D2	0	5	0.759E+00	0.511E-01	INTAKE VS DISCHARGE	0.175E+01	0.217E+00
12/05/78	1206	I5	0	4	0.941E+00	0.921E-01			
12/05/78	1215	D1	0	4	0.780E+00	0.115E+00			
12/05/78	1150	D2	0	3	0.905E+00	0.117E+00	INTAKE VS DISCHARGE	0.655E+00	0.547E+00

TABLE 47. Mean phaeophytin a concentrations (milligrams per cubic meter) with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and number of hours after collection it was incubated.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5	0	5	0.842E+00	0.136E+00			
01/10/78	0730	D1	0	5	0.121E+01	0.236E+00	INTAKE VS. DISCHARGE	0.179E+01	0.217E+00
01/10/78	0730	I5	27	5	0.109E+01	0.130E+00			
01/10/78	0730	D1	27	5	0.146E+01	0.331E+00	INTAKE VS. DISCHARGE	0.112E+01	0.323E+00
01/11/78	1400	I5	0	4	0.109E+01	0.895E-01			
01/11/78	1400	D1	0	4	0.718E+00	0.223E+00	INTAKE VS. DISCHARGE	0.237E+01	0.175E+00
01/11/78	1400	I5	4	2	0.881E+00	0.417E-06			
01/11/78	1400	D1	4	4	0.605E+00	0.357E+00	INTAKE VS. DISCHARGE	0.266E+00	0.632E+00
01/11/78	2000	I5	0	5	0.510E+00	0.122E+00			
01/11/78	2000	D1	0	5	0.468E+00	0.142E+00	INTAKE VS. DISCHARGE	0.518E-01	0.813E+00
02/06/78	2001	I5	0	5	0.114E+00	0.467E-01			
02/06/78	1950	D1	0	4	0.442E+00	0.634E-01	INTAKE VS. DISCHARGE	0.182E+02	0.461E-02
02/06/78	2001	I5	33	5	0.605E+00	0.942E-01			
02/06/78	1950	D1	33	5	0.205E+00	0.564E-01	INTAKE VS. DISCHARGE	0.132E+02	0.744E-02
02/08/78	0650	I5	0	5	0.303E+00	0.125E+00			
02/08/78	0650	D1	0	4	0.379E+00	0.130E+00	INTAKE VS. DISCHARGE	0.172E+00	0.687E+00
02/07/78	1215	I5	0	5	0.676E+00	0.206E+00			
02/07/78	1215	D1	0	5	0.321E+00	0.618E-01	INTAKE VS. DISCHARGE	0.272E+01	0.137E+00
03/06/78	2017	I5	0	5	0.578E+00	0.232E+00			
03/06/78	2017	D1	0	5	0.751E+00	0.129E+00	INTAKE VS. DISCHARGE	0.424E+00	0.537E+00
03/06/78	2017	I5	37	5	0.104E+01	0.518E+00			
03/06/78	2017	D1	37	5	0.112E+00	0.722E-01	INTAKE VS. DISCHARGE	0.315E+01	0.114E+00
03/07/78	0550	I5	0	4	0.780E+00	0.107E+00			
03/07/78	0550	D1	0	5	0.664E+00	0.132E+00	INTAKE VS. DISCHARGE	0.423E+00	0.539E+00
03/07/78	1230	I5	0	5	0.821E+00	0.238E+00			
03/07/78	1230	D1	0	5	0.578E+00	0.271E+00	INTAKE VS. DISCHARGE	0.454E+00	0.523E+00
04/10/78	2105	I5	0	5	0.658E+00	0.408E+00			
04/10/78	2105	D2	0	5	0.423E+00	0.170E+00	INTAKE VS. DISCHARGE	0.283E+00	0.611E+00
04/10/78	2105	I5	38	5	0.472E+00	0.163E+00			
04/10/78	2105	D2	38	5	0.328E+00	0.889E-01	INTAKE VS. DISCHARGE	0.603E+00	0.464E+00
04/11/78	0440	I5	0	5	0.180E+01	0.198E+00			
04/11/78	0440	D2	0	5	0.126E+01	0.397E+00	INTAKE VS. DISCHARGE	0.150E+01	0.256E+00

(continued)

TABLE 47. (continued).

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5 0	5	0.625E+00	0.192E+00			
04/11/78	1225	D2 0	5	0.421E+00	0.195E+00	INTAKE VS. DISCHARGE	0.559E+00	0.480E+00
05/09/78	2215	I5 0	5	0.182E+01	0.208E+00			
05/09/78	2215	D2 0	5	0.108E+01	0.293E+00	INTAKE VS. DISCHARGE	0.428E+01	0.723E-01
05/09/78	2215	I5 39	5	0.170E+01	0.134E+00			
05/09/78	2215	D2 39	5	0.161E+01	0.371E+00	INTAKE VS. DISCHARGE	0.467E-01	0.821E+00
05/10/78	0350	I5 0	5	0.949E+00	0.820E-01			
05/10/78	0340	D2 0	5	0.992E+00	0.190E+00	INTAKE VS. DISCHARGE	0.420E-01	0.829E+00
05/10/78	1219	I5 0	5	0.694E+00	0.214E+00			
05/10/78	1205	D2 0	4	0.501E+00	0.217E+00	INTAKE VS. DISCHARGE	0.388E+00	0.556E+00
06/12/78	2307	I5 0	5	0.297E+01	0.369E+00			
06/12/78	2310	D1 0	5	0.203E+01	0.211E+00	INTAKE VS. DISCHARGE	0.495E+01	0.569E-01
06/13/78	0010	I5 34	5	0.243E+01	0.491E+00			
06/13/78	2307	D1 34	5	0.235E+01	0.220E+00	INTAKE VS. DISCHARGE	0.232E-01	0.869E+00
06/13/78	0218	I5 0	5	0.254E+01	0.294E+00			
06/13/78	0220	D1 0	4	0.198E+01	0.672E+00	INTAKE VS. DISCHARGE	0.689E+00	0.438E+00
06/13/78	1237	I5 0	5	0.117E+01	0.258E+00			
06/13/78	1237	D1 0	5	0.117E+01	0.262E+00	INTAKE VS. DISCHARGE	0.358E-04	0.983E+00
07/11/78	2307	I5 0	5	0.363E+01	0.919E+00			
07/11/78	2315	D1 0	5	0.366E+01	0.847E+00			
07/11/78	2321	D2 0	5	0.391E+01	0.873E+00	INTAKE VS. DISCHARGE	0.303E-01	0.967E+00
07/11/78	2307	I5 34	5	0.125E+01	0.290E+00			
07/11/12	2315	D1 34	5	0.153E+01	0.319E+00			
07/11/78	2321	D2 34	5	0.193E+01	0.342E+00	INTAKE VS. DISCHARGE	0.116E+01	0.348E+00
07/11/78	0240	I5 0	5	0.203E+01	0.414E+00			
07/11/78	0240	D1 0	5	0.199E+01	0.578E+00			
07/11/78	0246	D2 0	5	0.265E+01	0.181E+00	INTAKE VS. DISCHARGE	0.768E+00	0.488E+00
07/11/78	1212	I5 0	5	0.103E+01	0.524E+00			
07/11/78	1213	D1 0	5	0.103E+01	0.257E+00			
07/11/78	1225	D2 0	5	0.858E+00	0.242E+00	INTAKE VS. DISCHARGE	0.753E-01	0.923E+00
08/07/78	2243	I5 0	5	0.144E+01	0.103E+00			
08/07/78	2238	D1 0	5	0.121E+01	0.954E-01			
08/07/78	2219	D2 0	5	0.987E+00	0.108E+00	INTAKE VS. DISCHARGE	0.482E+01	0.301E-01

(continued)

TABLE 47. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5	35	5	0.101E+01	0.664E-01			
08/07/78	2238	D1	35	3	0.726E+00	0.125E+00			
08/08/78	2219	D2	35	5	0.103E+01	0.114E+00	INTAKE VS. DISCHARGE	0.224E+01	0.158E+00
08/08/78	0340	I5	0	5	0.862E+00	0.700E-01			
08/08/78	0335	D1	0	5	0.126E+01	0.144E+00			
08/08/78	0335	D2	0	5	0.120E+01	0.116E+00	INTAKE VS. DISCHARGE	0.355E+01	0.628E-01
08/08/78	1233	I5	0	5	0.348E+00	0.892E-01			
08/08/78	1225	D1	0	5	0.679E+00	0.989E-01			
08/08/78	1229	D2	0	5	0.504E+00	0.580E-01	INTAKE VS. DISCHARGE	0.390E+01	0.506E-01
09/11/78	2115	I5	0	5	0.230E+00	0.802E-01			
09/11/78	2115	D1	0	5	0.391E+00	0.973E-01			
09/11/78	2115	D2	0	5	0.368E+00	0.119E+00	INTAKE VS. DISCHARGE	0.760E+00	0.492E+00
09/11/78	2115	I5	37	5	0.581E+00	0.469E-01			
09/11/78	2115	D1	37	5	0.333E+00	0.923E-01			
09/11/78	2115	D2	37	5	0.240E+00	0.132E+00	INTAKE VS. DISCHARGE	0.332E+01	0.725E-01
09/12/78	0555	I5	0	5	0.570E+00	0.855E-01			
09/12/78	0555	D1	0	5	0.749E+00	0.705E-01			
09/12/78	0554	D2	0	5	0.550E+00	0.110E+00	INTAKE VS. DISCHARGE	0.147E+01	0.270E+00
09/12/78	1207	I5	0	5	0.746E+00	0.656E-01			
09/12/78	1200	D1	0	5	0.747E+00	0.784E-01			
09/12/78	1215	D2	0	5	0.799E+00	0.841E-01	INTAKE VS. DISCHARGE	0.156E+00	0.853E+00
10/09/78	2007	I5	0	5	0.139E+01	0.332E+00			
10/09/78	2000	D1	0	5	0.180E+01	0.513E+00			
10/09/78	2004	D2	0	4	0.551E+00	0.215E+00	INTAKE VS DISCHARGE	0.240E+01	0.138E+00
10/09/78	2007	I5	36	5	0.781E+00	0.245E+00			
10/09/78	2000	D1	36	5	0.231E+01	0.389E+00			
10/09/78	2004	D2	36	5	0.252E+01	0.277E+00	INTAKE VS DISCHARGE	0.938E+01	0.427E-02
10/10/78	0533	I5	0	5	0.863E+00	0.137E+00			
10/10/78	0520	D1	0	4	0.527E+00	0.128E+00			
10/10/78	0523	D2	0	4	0.507E+00	0.244E+00	INTAKE VS DISCHARGE	0.144E+01	0.283E+00
10/10/78	1218	I5	0	5	0.792E+00	0.172E+00			
10/10/78	1200	D1	0	5	0.937E+00	0.274E+00			
10/10/78	1213	D2	0	5	0.923E+00	0.215E+00	INTAKE VS DISCHARGE	0.126E+00	0.877E+00

(continued)

TABLE 47. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5	0	3	0.457E+00	0.278E+00			
11/13/78	1910	D1	0	5	0.745E+00	0.211E+00	INTAKE VS DISCHARGE	0.687E+00	0.442E+00
11/13/78	1925	I5	36	5	0.378E+00	0.117E+00			
11/13/78	1910	D1	36	5	0.752E+00	0.131E+00	INTAKE VS DISCHARGE	0.452E+01	0.663E-01
11/14/78	0615	I5	0	5	0.686E+00	0.175E+00			
11/14/78	0557	D1	0	4	0.925E+00	0.314E+00	INTAKE VS DISCHARGE	0.494E+00	0.508E+00
11/14/78	1215	I5	0	4	0.669E+00	0.293E+00			
11/14/78	1200	D1	0	5	0.131E+01	0.281E+00	INTAKE VS DISCHARGE	0.245E+01	0.162E+00
12/04/78	1910	I5	0	5	0.219E+01	0.934E+00			
12/04/78	1931	D1	0	5	0.303E+01	0.129E+01			
12/04/78	1900	D2	0	5	0.595E+00	0.183E+00	INTAKE VS DISCHARGE	0.178E+01	0.211E+00
12/04/78	1910	I5	34	5	0.998E+00	0.230E+00			
12/04/78	1931	D1	34	5	0.493E+00	0.188E+00			
12/04/78	1900	D2	34	5	0.507E+00	0.126E+00	INTAKE VS DISCHARGE	0.237E+01	0.137E+00
12/05/78	0620	I5	0	5	0.374E+00	0.222E+00			
12/05/78	0635	D1	0	5	0.647E+00	0.241E+00			
12/05/78	0610	D2	0	5	0.240E+01	0.126E+01	INTAKE VS DISCHARGE	0.212E+01	0.164E+00
12/05/78	1206	I5	0	4	0.215E+01	0.969E+00			
12/05/78	1215	D1	0	4	0.743E+00	0.279E+00			
12/05/78	1150	D2	0	3	0.495E+00	0.172E+00	INTAKE VS DISCHARGE	0.191E+01	0.211E+00

TABLE 48. Mean phaeophytin a to chlorophyll a ratio with standard errors and comparison of means using one-way analysis of variance. The INC. column is sample type (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=discharge) and number of hours after collection it was incubated.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5 0	5	0.196E+00	0.371E-01			
01/10/78	0730	D1 0	5	0.244E+00	0.363E-01	INTAKE VS. DISCHARGE	0.858E+00	0.384E+00
01/10/78	0730	I5 27	5	0.240E+00	0.255E-01			
01/10/78	0730	D1 27	5	0.368E+00	0.911E-01	INTAKE VS. DISCHARGE	0.184E+01	0.212E+00
01/11/78	1400	I5 0	4	0.286E+00	0.267E-01			
01/11/78	1400	D1 0	4	0.984E-01	0.301E-01	INTAKE VS. DISCHARGE	0.218E+02	0.448E-02
01/11/78	1400	I5 4	2	0.232E+00	0.0			
01/11/78	1400	D1 4	4	0.198E+00	0.121E+00	INTAKE VS. DISCHARGE	0.341E-01	0.848E+00
01/11/78	2000	I5 0	5	0.161E+00	0.312E-01			
01/11/78	2000	D1 0	5	0.130E+00	0.380E-01	INTAKE VS. DISCHARGE	0.388E+00	0.554E+00
02/06/78	2001	I5 0	5	0.100E+00	0.417E-01			
02/06/78	1950	D1 0	4	0.332E+00	0.628E-01	INTAKE VS. DISCHARGE	0.102E+02	0.161E-01
02/06/78	2001	I5 33	5	0.463E+00	0.833E-01			
02/06/78	1950	D1 33	5	0.133E+00	0.372E-01	INTAKE VS. DISCHARGE	0.131E+02	0.758E-02
02/08/78	0650	I5 0	5	0.239E+00	0.109E+00			
02/08/78	0650	D1 0	4	0.368E+00	0.162E+00	INTAKE VS. DISCHARGE	0.472E+00	0.518E+00
02/07/78	1215	I5 0	5	0.127E+01	0.664E+00			
02/07/78	1215	D1 0	5	0.267E+00	0.679E-01	INTAKE VS. DISCHARGE	0.226E+01	0.171E+00
03/06/78	2017	I5 0	5	0.314E+00	0.146E+00			
03/06/78	2017	D1 0	5	0.364E+00	0.794E-01	INTAKE VS. DISCHARGE	0.900E-01	0.763E+00
03/06/78	2017	I5 37	5	0.447E+00	0.235E+00			
03/06/78	2017	D1 37	5	0.445E-01	0.296E-01	INTAKE VS. DISCHARGE	0.289E+01	0.127E+00
03/07/78	0550	I5 0	4	0.428E+00	0.802E-01			
03/07/78	0550	D1 0	5	0.356E+00	0.782E-01	INTAKE VS. DISCHARGE	0.405E+00	0.548E+00
03/07/78	1230	I5 0	5	0.511E+00	0.171E+00			
03/07/78	1230	D1 0	5	0.402E+00	0.200E+00	INTAKE VS. DISCHARGE	0.173E+00	0.686E+00
04/10/78	2105	I5 0	5	0.426E+00	0.346E+00			
04/10/78	2105	D2 0	5	0.136E+00	0.568E-01	INTAKE VS. DISCHARGE	0.683E+00	0.436E+00
04/10/78	2105	I5 38	5	0.147E+00	0.575E-01			
04/10/78	2105	D2 38	5	0.102E+00	0.313E-01	INTAKE VS. DISCHARGE	0.481E+00	0.511E+00
04/11/78	0440	I5 0	5	0.113E+01	0.247E+00			
04/11/78	0440	D2 0	5	0.812E+00	0.367E+00	INTAKE VS. DISCHARGE	0.533E+00	0.490E+00

(continued)

TABLE 48. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5	0	5	0.234E+00	0.821E-01			
04/11/78	1225	D2	0	5	0.142E+00	0.717E-01	INTAKE VS. DISCHARGE	0.705E+00	0.429E+00
05/09/78	2215	I5	0	5	0.161E+00	0.202E-01			
05/09/78	2215	D2	0	5	0.899E-01	0.252E-01	INTAKE VS. DISCHARGE	0.482E+01	0.596E-01
05/09/78	2215	I5	39	5	0.133E+00	0.101E-01			
05/09/78	2215	D2	39	5	0.131E+00	0.360E-01	INTAKE VS. DISCHARGE	0.247E-02	0.951E+00
05/10/78	0350	I5	0	5	0.708E-01	0.750E-02			
05/10/78	0340	D2	0	5	0.720E-01	0.132E-01	INTAKE VS. DISCHARGE	0.648E-02	0.926E+00
05/10/78	1219	I5	0	5	0.601E-01	0.190E-01			
05/10/78	1205	D2	0	4	0.451E-01	0.184E-01	INTAKE VS. DISCHARGE	0.310E+00	0.596E+00
06/12/78	2307	I5	0	5	0.249E+00	0.316E-01			
06/12/78	2310	D1	0	5	0.169E+00	0.203E-01	INTAKE VS. DISCHARGE	0.454E+01	0.658E-01
06/13/78	0010	I5	34	5	0.225E+00	0.505E-01			
06/13/78	2307	D1	34	5	0.198E+00	0.211E-01	INTAKE VS. DISCHARGE	0.247E+00	0.633E+00
06/13/78	0218	I5	0	5	0.166E+00	0.222E-01			
06/13/78	0220	D1	0	4	0.154E+00	0.552E-01	INTAKE VS. DISCHARGE	0.515E-01	0.814E+00
06/13/78	1237	I5	0	5	0.943E-01	0.219E-01			
06/13/78	1237	D1	0	5	0.102E+00	0.251E-01	INTAKE VS. DISCHARGE	0.591E-01	0.802E+00
07/11/78	2307	I5	0	5	0.241E+00	0.723E-01			
07/11/78	2315	D1	0	5	0.259E+00	0.675E-01			
07/11/78	2321	D2	0	5	0.254E+00	0.801E-01	INTAKE VS. DISCHARGE	0.161E-01	0.982E+00
07/11/78	2307	I5	34	5	0.654E-01	0.154E-01			
07/11/12	2315	D1	34	5	0.975E-01	0.219E-01			
07/11/78	2321	D2	34	5	0.100E+00	0.180E-01	INTAKE VS. DISCHARGE	0.107E+01	0.376E+00
07/11/78	0240	I5	0	5	0.134E+00	0.304E-01			
07/11/78	0240	D1	0	5	0.140E+00	0.418E-01			
07/11/78	0246	D2	0	5	0.182E+00	0.143E-01	INTAKE VS. DISCHARGE	0.709E+00	0.514E+00
07/11/78	1212	I5	0	5	0.973E-01	0.514E-01			
07/11/78	1213	D1	0	5	0.105E+00	0.269E-01			
07/11/78	1225	D2	0	5	0.795E-01	0.225E-01	INTAKE VS. DISCHARGE	0.132E+00	0.873E+00
08/07/78	2243	I5	0	5	0.360E+00	0.298E-01			
08/07/78	2238	D1	0	5	0.316E+00	0.324E-01			
08/07/78	2219	D2	0	5	0.220E+00	0.252E-01	INTAKE VS. DISCHARGE	0.606E+01	0.161E-01

(continued)

TABLE 48. (continued).

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5 35	5	0.262E+00	0.247E-01			
08/07/78	2238	D1 35	3	0.198E+00	0.359E-01			
08/08/78	2219	D2 35	5	0.268E+00	0.355E-01	INTAKE VS. DISCHARGE	0.117E+01	0.352E+00
08/08/78	0340	I5 0	5	0.224E+00	0.225E-01			
08/08/78	0335	D1 0	5	0.275E+00	0.345E-01			
08/08/78	0335	D2 0	5	0.340E+00	0.457E-01	INTAKE VS. DISCHARGE	0.266E+01	0.112E+00
08/08/78	1233	I5 0	5	0.150E+00	0.414E-01			
08/08/78	1225	D1 0	5	0.374E+00	0.644E-01			
08/08/78	1229	D2 0	5	0.234E+00	0.278E-01	INTAKE VS. DISCHARGE	0.579E+01	0.184E-01
09/11/78	2115	I5 0	5	0.129E+00	0.461E-01			
09/11/78	2115	D1 0	5	0.265E+00	0.903E-01			
09/11/78	2115	D2 0	5	0.281E+00	0.102E+00	INTAKE VS. DISCHARGE	0.100E+01	0.398E+00
09/11/78	2115	I5 37	5	0.544E+00	0.567E-01			
09/11/78	2115	D1 37	5	0.273E+00	0.850E-01			
09/11/78	2115	D2 37	5	0.240E+00	0.148E+00	INTAKE VS. DISCHARGE	0.259E+01	0.117E+00
09/12/78	0555	I5 0	5	0.277E+00	0.560E-01			
09/12/78	0555	D1 0	5	0.433E+00	0.459E-01			
09/12/78	0554	D2 0	5	0.271E+00	0.575E-01	INTAKE VS. DISCHARGE	0.296E+01	0.913E-01
09/12/78	1207	I5 0	5	0.240E+00	0.234E-01			
09/12/78	1200	D1 0	5	0.252E+00	0.272E-01			
09/12/78	1215	D2 0	5	0.229E+00	0.248E-01	INTAKE VS. DISCHARGE	0.202E+00	0.817E+00
10/09/78	2007	I5 0	5	0.159E+00	0.467E-01			
10/09/78	2000	D1 0	5	0.198E+00	0.625E-01			
10/09/78	2004	D2 0	4	0.591E-01	0.242E-01	INTAKE VS DISCHARGE	0.191E+01	0.196E+00
10/09/78	2007	I5 36	5	0.795E-01	0.261E-01			
10/09/78	2000	D1 36	5	0.280E+00	0.556E-01			
10/09/78	2004	D2 36	5	0.319E+00	0.421E-01	INTAKE VS DISCHARGE	0.897E+01	0.492E-02
10/10/78	0533	I5 0	5	0.110E+00	0.190E-01			
10/10/78	0520	D1 0	4	0.665E-01	0.170E-01			
10/10/78	0523	D2 0	4	0.635E-01	0.310E-01	INTAKE VS DISCHARGE	0.140E+01	0.293E+00
10/10/78	1218	I5 0	5	0.106E+00	0.230E-01			
10/10/78	1200	D1 0	5	0.137E+00	0.411E-01			
10/10/78	1213	D2 0	5	0.138E+00	0.336E-01	INTAKE VS DISCHARGE	0.310E+00	0.739E+00

(continued)

TABLE 48. (continued).

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5	0	3	0.899E-01	0.554E-01			
11/13/78	1910	D1	0	5	0.164E+00	0.530E-01	INTAKE VS DISCHARGE	0.817E+00	0.404E+00
11/13/78	1925	I5	36	5	0.722E-01	0.246E-01			
11/13/78	1910	D1	36	5	0.161E+00	0.329E-01	INTAKE VS DISCHARGE	0.462E+01	0.640E-01
11/14/78	0615	I5	0	5	0.122E+00	0.349E-01			
11/14/78	0557	D1	0	4	0.174E+00	0.595E-01	INTAKE VS DISCHARGE	0.634E+00	0.456E+00
11/14/78	1215	I5	0	4	0.981E-01	0.453E-01			
11/14/78	1200	D1	0	5	0.201E+00	0.480E-01	INTAKE VS DISCHARGE	0.232E+01	0.171E+00
12/04/78	1910	I5	0	5	0.437E+00	0.205E+00			
12/04/78	1931	D1	0	5	0.701E+00	0.334E+00			
12/04/78	1900	D2	0	5	0.865E-01	0.272E-01	INTAKE VS DISCHARGE	0.185E+01	0.200E+00
12/04/78	1910	I5	34	5	0.143E+00	0.344E-01			
12/04/78	1931	D1	34	5	0.925E-01	0.428E-01			
12/04/78	1900	D2	34	5	0.893E-01	0.251E-01	INTAKE VS DISCHARGE	0.752E+00	0.495E+00
12/05/78	0620	I5	0	5	0.548E-01	0.319E-01			
12/05/78	0635	D1	0	5	0.107E+00	0.417E-01			
12/05/78	0610	D2	0	5	0.584E+00	0.330E+00	INTAKE VS DISCHARGE	0.229E+01	0.145E+00
12/05/78	1206	I5	0	4	0.388E+00	0.295E+00			
12/05/78	1215	D1	0	4	0.111E+00	0.432E-01			
12/05/78	1150	D2	0	3	0.699E-01	0.254E-01	INTAKE VS DISCHARGE	0.169E+01	0.245E+00

no consistent viability increase or decrease has been observed which can be attributed to the nuclear power plant.

Monthly Variation of the Chlorophylls and Phaeophytin a

Figures 15 through 19 illustrate the variation of chlorophyll a, chlorophyll b, chlorophyll c, phaeophytin a, and the phaeophytin a to chlorophyll a ratio during 1978 at the intake forebay of the Donald C. Cook Nuclear Plant. Chlorophylls a and c were relatively high during May, June, and July. These high concentrations reflect a delayed spring diatom bloom in May and upwellings in June and July. Increased concentrations of chlorophyll a in October through December reflect an increase in phytoplankton numbers. Chlorophyll b was relatively low during April, May, June, and July. Phaeophytin a exhibited peaks in its concentration during June and July. This coincided with upwelling events in June and July which may have provided less viable phytoplankton from the hypolimnion to the nearshore zone. The phaeophytin a/chlorophyll a ratio was notably higher in February, March, and April and ranged from 0.1 to 0.3 during the other months.

SUMMARY

Nutrient concentrations PO_4-P, NO_3-N, and SiO_2 were high in the January through July 1978 samples, decreased sharply in August and September during the period of extended thermal stratification, and remained low through December. Orthophosphate concentrations in 1978 ranged from 0.14 to 4.1 ppb. Lowest concentrations were in August, and the highest were in January. Nitrate concentrations varied from 0.0 to 0.45 ppm, with lows in September, October,

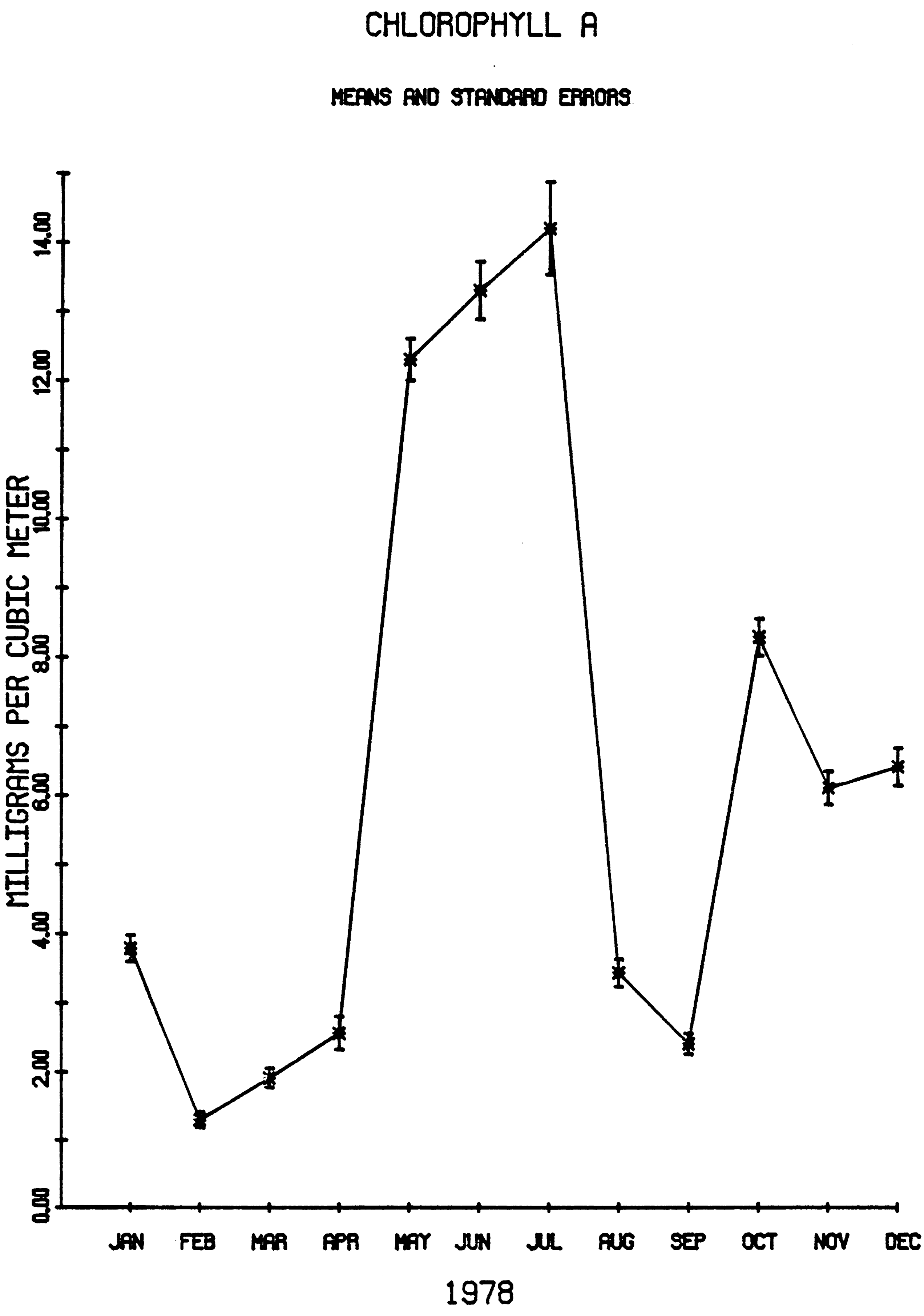

FIG. 15. Variation of chlorophyll _a_ concentrations during 1978.

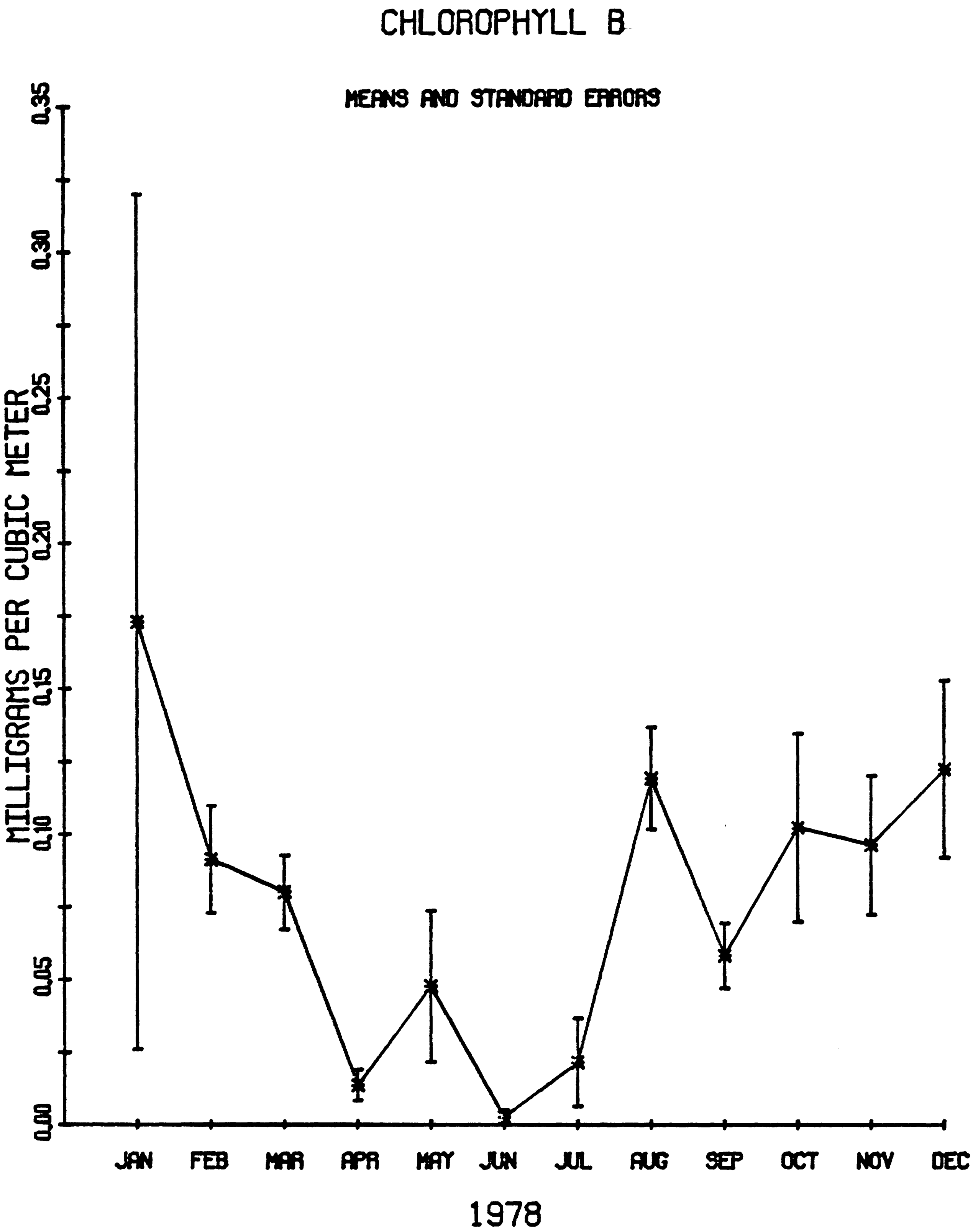

FIG. 16. Variation of chlorophyll b concentrations during 1978.

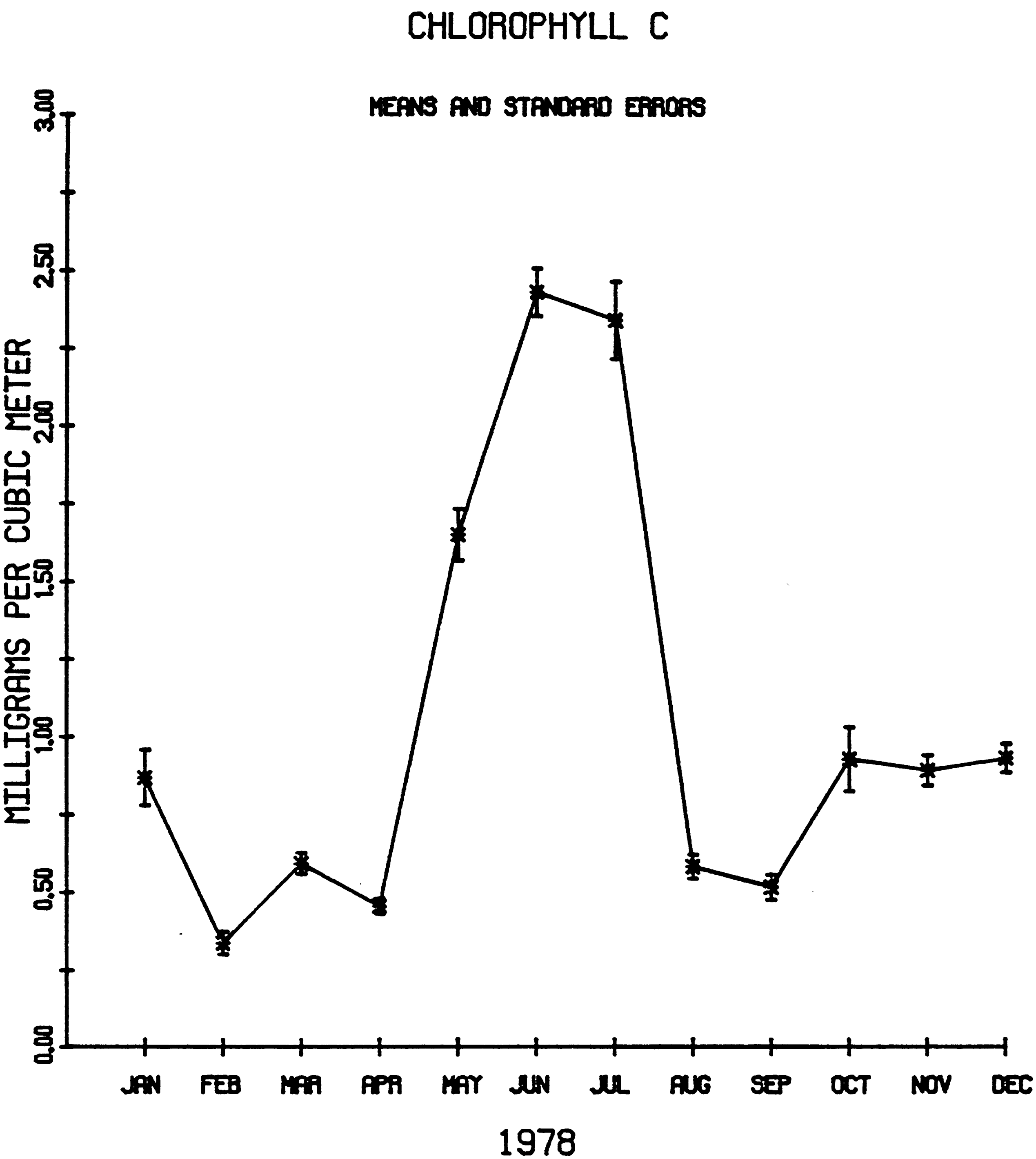

FIG. 17. Variation of chlorophyll $\underline{c}$ concentrations during 1978.

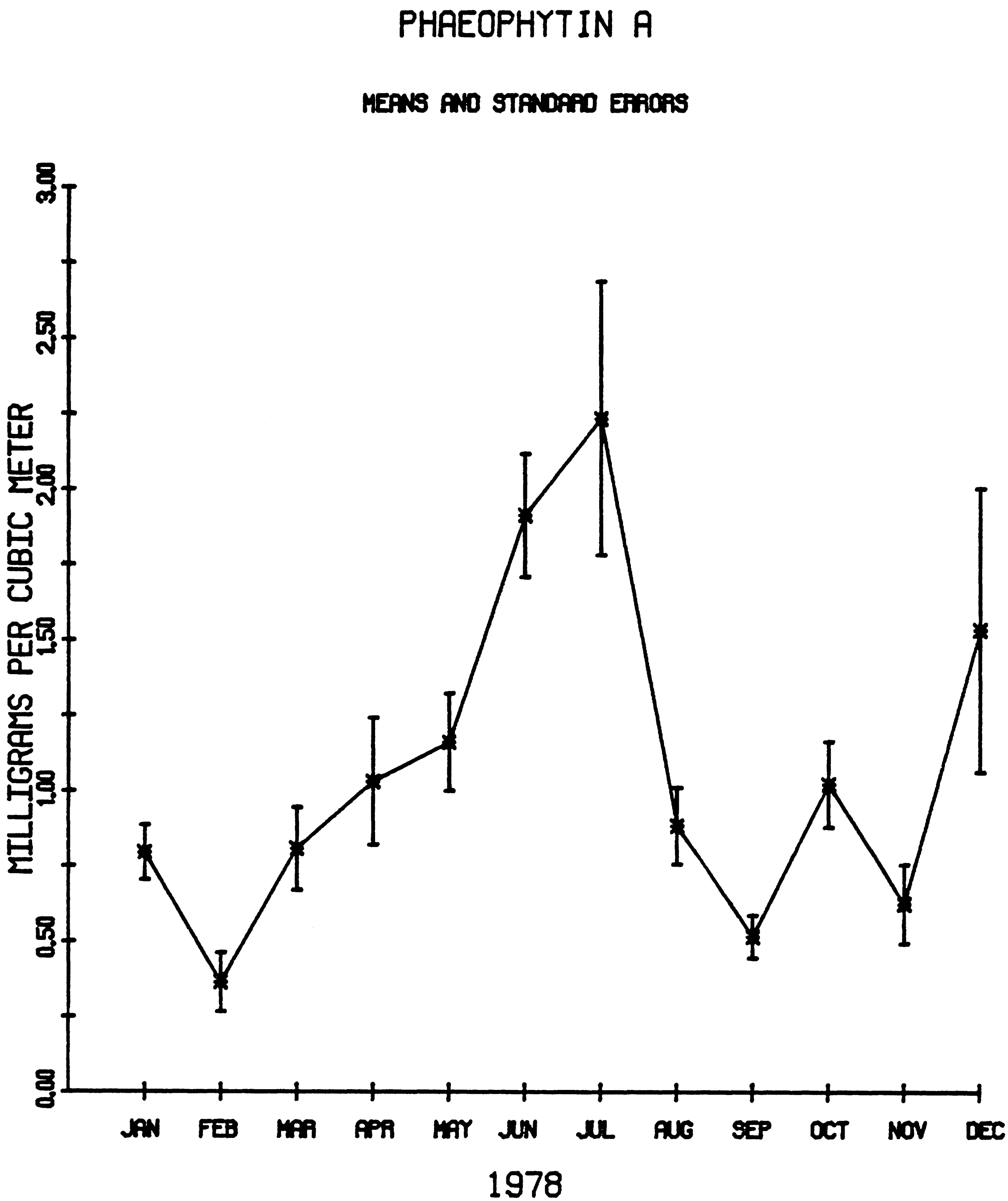

FIG. 18. Variation of phaeophytin a concentrations during 1978.

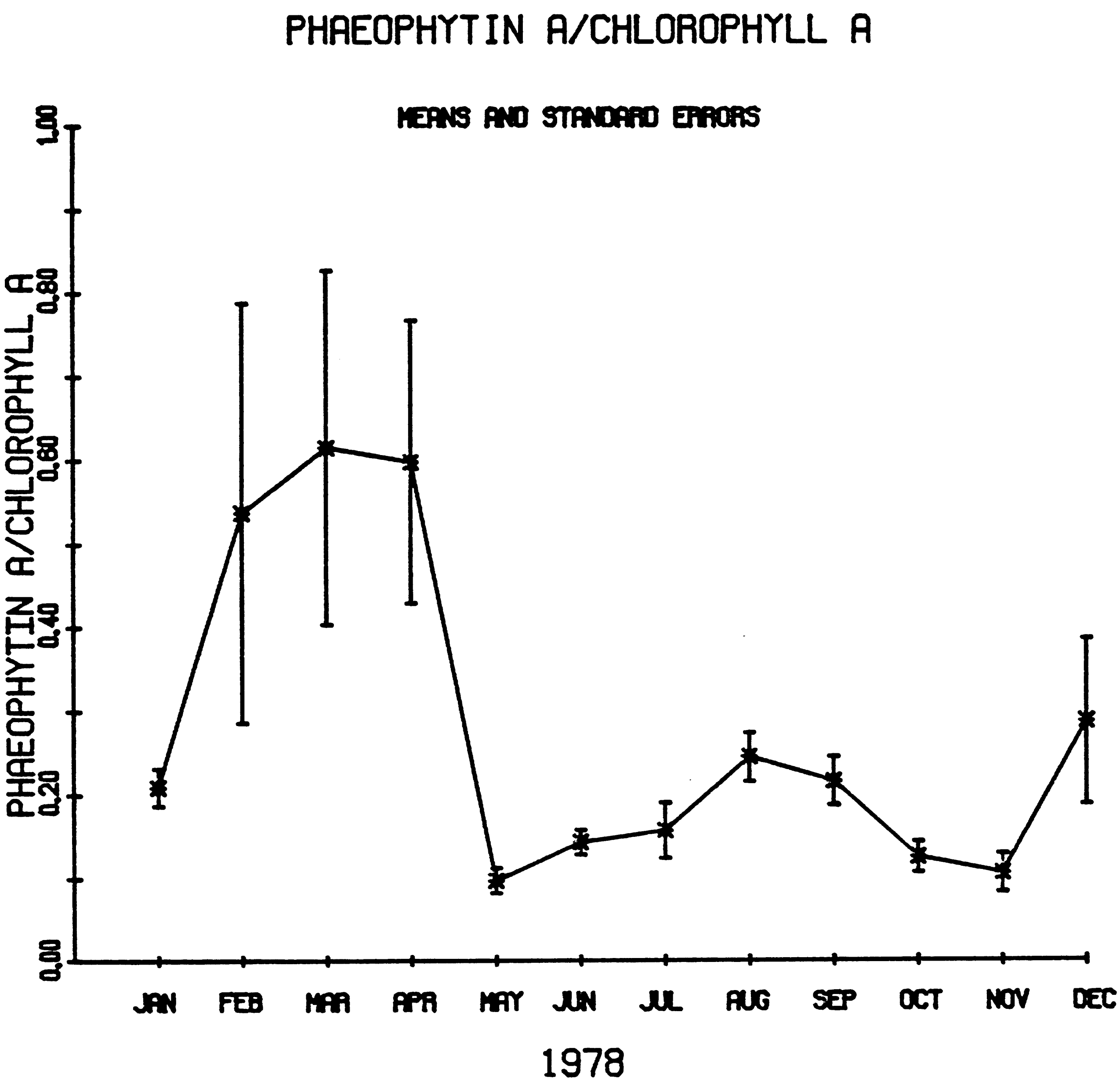

FIG. 19. Variation of the phaeophytin a/chlorophyll a ratio during 1978.

and November and the highest concentration in January. Dissolved silica concentrations were below 0.5 ppm in May, September, and December and ranged between 0.36 and 1.1 ppm.

Coccoid blue-green algae were low in concentration during March through May and high in concentration from September through December. Filamentous blue-green algae were less numerous than coccoid blue-green algae. The maximum count was 111 cells/mL occurring in June and August. Coccoid green algae numbers were relatively high during August through December. Filamentous green algae were above 15 cells/mL only in November and December. Flagellates were numerous and contributed an important share to the total annual algal population. They peaked in June and maintained a relatively low density in February, March, and the period from August through November. Centric diatoms were abundant in May through July and pennate diatoms were most abundant in May through July and October. Desmid numbers were consistently low, with a peak in July. Other algae maintained high numbers during July and October. Total algae numbers were highest in June, October, and November.

Comparison of phytoplankton major group mean concentrations for 1975 through 1978 gave the following general observations: 1) a trend toward an increase in coccoid blue-green algae since 1976 was observed; 2) flagellates were most abundant during 1976; and 3) filamentous blue-green algae, coccoid green algae, centric diatoms, pennate diatoms, and total algae were least abundant in 1977.

The number of forms of phytoplankton identified during 1978 varied from 40 in March to 85 in June. Diversity ranged from 2.91 in December to 4.98 in May, and redundancy varied from 0.293 in July to 0.595 in December.

The average number of forms and the redundancy index were highest in 1978,

and diversity was highest in 1976 and lowest in 1977. These changes in community structure statistics mimic changes noted in the major forms of phytoplankton. The appearance of the maximum number of forms at the same time as the highest redundancy is an indication of the increasing dominancy of relatively few forms in the system despite the increase in overall species number in the system.

During 1978, a general reduction in occurrences of diatom species was noted. Mesotrophic diatom species tolerant of moderate nutrient enrichment ceased their increasing trend and began to decrease, while those species intolerant of moderate nutrient enrichment never constituted more than 10% of any count in the 1978 samples. Replacing this was a trend of increase in the number of occurrences of the blue-green algae *Anacystis incerta* and *Gomphosphaeria lacustris*.

Viability results based on the comparisons of chlorophyll and phaeophytin *a* concentrations in the intake and the discharge samples were variable and lacked consistent trends in the years (1975-1978) under consideration. Decreases in viability occurred in 9% of the samples in 1978 compared to 3% in 1975, 5% in 1976, and 16% in 1977. Viability increased in 9% of the 1978 samples, 1% in 1977, 4% in 1976, and 2% in 1975. Except for 1977, this variation is believed to be related to natural changes in the phytoplankton community and to the patchy distribution of phytoplankton.

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